Wingate's Rule

OF

PROPORTION,

ARITHMETICK

AND

GEOMETRY:

GUNTER'S LINE

Newly rectified by Mr. Brown and Mr. Ackinson, Teachers of the Mathematicks.

Fitted for all Artists for Measuring and Building.

Whereinto is now also inserted the Confiruction of the same Rule, and a farther. Use thereof, in Questions that concern

Aftronomy, Dialling, Military Orders, Geography, Interest and Annuities.

on, Printed by R. H. for W. Fifter, T. Juffinger, R. Boulter, and R. Smith, 1683.

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TO MY Worthy Friend,

MATHEMATICIAN,
Mr. Fobn Collins

O F

LONDON.

SIR.

Ot long after my Arrival in this City, having divulged the Instrument (whose U-ses I explain in this little Treatise) and discoursed of some of the conveniences thereof, I was given to understand by A 4 divers

The Epistle Dedicatory.

divers, that if pains were bestowed upon that Subject, the Labour therein taken might obtain good Reception: This (to say truth) hath given me Encouragement thereof to say somewhat, and (having caused it to see the Light) to shelter it under your Protection: Nevertheless you shall pardon me, for that by presuming to procure unto it from thence Credit and Recommendation I have expressed a willingness to testifie, how much I am,

Your Servant,

Edmond Wingate.

THE

PREFACE

TO THIS

TRANSLATION.

there published) coming for

Mongst the many rare Effects produced by the noble Invention of Logarithmes, the projection of the Rule of Proportion is not the least, which being first discovered by that Learned and Industrious Artist Edm. Gunter (late Professor of Astronomy in Gresham Colledge, London, deceased) was by me (in Anno 1624.) transported into France, and there communicated to most of the chief-

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est Mathematicians then residing in Paris, who apprehending the great benefit that might accrue thereby, importuned me to express the use thereof in the French Tongue; which being performed accordingly, I was advised by Mr. Alleaume (the King's Chief Ingenier) to dedicate my Book to Mensieur, the then King's only Brother, now Duke of Orleance: Nevertheless this Work (as it was there published) coming forth as an Abortive, the publishing thereof being fomewhat haftned, by reason an Advocate of Dijon in Burgundy began to print fome Uses thereof, which I had in a friendly way communicated unto him) I thought it not worthy to fee the Light here in England, especially in regard Mr. Gunter himself had learnedly explained the use thereof in a far larger Volume: Howbeit having now of late by reason of the present Troubles) had too much leisure from

from my other Employments and Calling, to look back to those Studies, wherewithin my younger time I used to busie my felf; And having also upon that occasion bethought my felf, how divers necessary Additions might be fitly inferted into that Work, and many inconveniences in the use of that Instrument, which before did usually incumber the Practitioner, might be removed; I have adventured to let this Translation appear; In which you shall find expressed, as succinctly and plainly as I could, the use of that Rule in the form as you find it annexed to this Book; Not that I would confine any man to ale fuch a form and no other, but because the Operations are thereupon upderstood and performed more perfpicuoufly and plainly, then (as I conceive) they would be ; it the Lines were thereupon otherwife described; Howbeit the use thereof.

of being in this form once gained, the Practitioner may then use that way of describing it, which sorts

best with his own humor.

Having thus acquainted you with the occasion of publishing this Treatife, left I may now expose it to prejudice, give me leave to premise these few Advertisements following : First, therefore, it is desired, that he, who intends to read this Book with profit, should have a proper Genius and Phansie for the Mathematicks, not only ready to conceive Mathematical Notions; but likewise able to wrestle with them, and apt to take pleasure in them: For, De quolibet ligno non fit Mercurine. Again, it is expected he should be aforehand furnished with competent knowledge in those Sciences, viz. t. In Arithmetick he ought to be acquainted with the Nature of Numbers, whole and broken, abfoluteand relative; with Numeration,

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tion, Addition, Substraction, Multiplication, Division, the Rule of Three, direct and inverse; with the Nature and Extraction of Roots, Square and Cube; And with the right use of Logarithms: 2. In Geometry, to be verst in the Doctrine of Triangles, plain and spherical, and (in some competent measure) to know their nature, together with the way and reason of their dimenfion; As also the dimension of other Geometrical Figures: 3. In Astronomy, Dialling, and Geography, to understand that the Problems which concern them, are refolved by the particular application of the Doctrine of Spherical Triangles to those several Sciences: 4. In Navigation, to be indifferently well read in fuch Authors as have explained that Art, and to be able therein also to make use of the Do-Arine of Triangles of With the knowledge of these things (I say) and

and the like he ought to be (in some reasonable fort) supplied, that intends to make a right and complete use of this Treatise: For, none (I presume) will expect to find an intire Body of the Mathematicks in this fmall Bulk, which is only intended for an Enchiridion or Manuel of fuch Mathematical Rules and Analogies, as may most properly ferve for the resolution of Problems, which may be wrought upon this Instrument: And therefore I wholly refer the Reader for demonstrations and larger explanations of the matters in this Book contained, to the further ferutiny of othen Authors; Not doubting but that (upon due perufal hereof) he will find as much inferted, as fhell be thought necessary to discover the manifold and exquisite use of the fame Infirument o But; here I would not be mistaken, as if I did totally exclude all others, who are

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not prepared with fuch an Univerfal Knowledge in the Mathematicks, from having any capacity at all of understanding this Book; For, if he be only in part acquainted with fome of the abovementioned Learning, he may be able to make use of this Instrument according to that degree of Knowledge which he hath therein; For Example, if he only know Multiplication and Division, this Treatife will instruct him how to multiply and divide upon the Rule, and fo in like fort of the rest: Howbeit (as I faid before) if he intend to have an intire understanding of the uses of this Instrument, he must be also furnished with an intire knowledge of all the Mathematicks; because it is subservient to every Branch of those Sciences: And then the conveniency thereof will have fuch Latitude; that it will not be confined to those uses only promifed in the Title of this Book, but likewife

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likewife (by the variety of Rules and Examples therein found) may be readily and fitly applied to other Arts and Professions not there remembred; As namely, in Fortificat tion, the Ingenier may here be taught how to find the Sides of his Polygonical Figures, the Lines of Fortification according to the Rules of that Art, the quantity of Trenches and Ramparts, how to order and estimate the labour and work of Pioners, and the like. The Surveyor also may here furnish himself with divers expeditious dispatches, for the taking of distances, the summing up of Plots, being first divided into Triangles, the distribution of Fields or Lordships to feveral Persons, the cutting off any part of a Triangle or Plot according to any quantity propounded, or The Sc like may be faid of Musick, Archi- co tecture, the Prospectives, Gummery, &c. ry The Goldfmith alfo, and Mint-Ma- Per

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fer may here learn how to temper their Allegations : The Merchant and Tradesman, how to resolve questions of Partnership, and to cast up the value of their Commodities: The Justice of Peace and High Constable, how to rate a Town, Hundred, or County, &c. All which and much more must be wholly left to the discretion of those, that will take the pains to understand the use of the said Instrument; which (I perswade my self) no man (affe-Cting the Mathematicks) will think much to undergo, confidering the benefit he may reap thereby, and the delight he may take therein; For, by help thereof, and of a pair of Compasses, only fix Inches long, he may refolve with requisite exactness any Proposition in the Arts and Sciences above remembred (which The chi- comes within the bounds of ordinagre, ry practice) without the help of Ma. Pen or Paper, and shall thereby also perform

perform more in one hour, then otherwife (I mean by ordinary Arithmerick) he shall be able to difpatchin two whole days. 10 and

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But it may be objected, if this Instrument be of fuch excellent use as is here pretended, why hath it not been heretofore of greater esteem, it heing nove above twenty years fince it was first invented? This Objection may be answered divers ways: 1. It is no easie matter to drive men out of their old track, especially when they have entertained an opinion that there can be none better. 2. Again, the use thereof in the point of Numbring upon the Rule (which ought to be accounted the chiefest, and indeed the ground of all the rest) hath not been heretofore (under favour) fo fully explained, as here you shall find it: For, albeit (I confess) it th were great presumption in me to on assume to my self the reputation of Pr having mioling

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having better abilities to describe any of the uses thereof, then Mr. Gwaer himfelf had, who first invented it; yet this I can aver upon mine own knowledge, that he did forbear to explain the use thereof, because he took it for granted none would meddle with it but fuch only as were already well able to understand how to number upon it, having before-hand acquainted themfelves with the manner of Numbring upon Scales, and with the nature of Logarithms: For, when after my return out of France, I importuned him to make a fuller explanation, how to number upon it, to the end the use thereof might by that means be made more publick, his answer was, That it could not be expected the Rule Should Speak; Intimating thereby, that the Practitioner should (in it that point) rely much upon discretito on, and not altogether depend upon of Precepts and Examples. But last-

ly, the chiefest causes why this Ine i strument hath been hitherto obscu--1 red and the uses thereof no better a known to the World, are thefe. 1. The Difficulty of describing the t t Lines thereupon with convenient exactness: 2. The trouble of work- e ing thereupon by reason (some- e times) of too large an extent of the t Compasses: 3. The importableness t thereof, it being requisite for work- v ing upon fuch a Rule (only two foot I long) to use a pair of Compasses of y nine Inches: 4. The charge of pur- u chasing such an Instrument made of a Brass or Wood; For, none but o fuch have been heretofore used. le For remedy of the first of these, I P have caused the Plate, whereupon if this Instrument is Printed, to be u protracted with a great deal of care u and circumspection, so that I dare w affirm it to be as exactly drawn (for co the main and most considerable Di-Pa visions thereof) as may be expect-ui cd

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ed from Art: For the second, having there three feveral Lines of Numbers by degrees one less than another, when the Compailes are too little for one, you may use another, also Croß-work upon the greatest Line will prevent the too great extension of the Compasses; so he that it will be requisite to use with ess this Instrument (as it is now contrik- ved) a pair of Compasses only fix oot Inches long, as I faid before; and of yet the Divisions of this (I mean ur- upon the great Line of Numbers) of are near as large again, as those upbut on Mr. Gunter's Rule of the like fed. length: The third and fourth ime, I pediments may also be remedied, oon if in stead of Brass or Wood you be use the impression of the said Plate care upon Vellum or Imperial Paper, lare which may either be rolled up and for couched in a little Box, or otherwise Di-pasted upon a Ruler, either flat, to ect. use at home, or round, to be carried cd

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in a hollow Staff or Cane together with the Compasses, which are to be used therewith. Also divers useful conveniences shall you meet withall in this Edition of the Rule; as namely, a readier way of finding out Mean-Proportions, the Extraction of Roots by inspection only, without aid of Pen or Compalles, and the like: For further discovery of 7 all which I refer you to the Book it I felf, hoping that my real intention 2 to advance the Publick Good will procure from the Ingenuous Reader a favourable construction of what he shall therein find not wilfully miftaken.

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A T Cherry-Garden Stairs on Rotherhuh Wall, are taught these Mathematical Sciences, siz. Arithmetick, Geometry, Algebra, Trigonometry, Navigation, Dialling, Aftronomy, Surveying, Gauging, Fortification, and Gunnery; The use of the Globes, and also other Mathematical Instruments; likewise the Projecting of the Sphere, or any Circle, &c. And other Parts of the Mathematicks, and Merchams Accounts.

By James Atkinson.

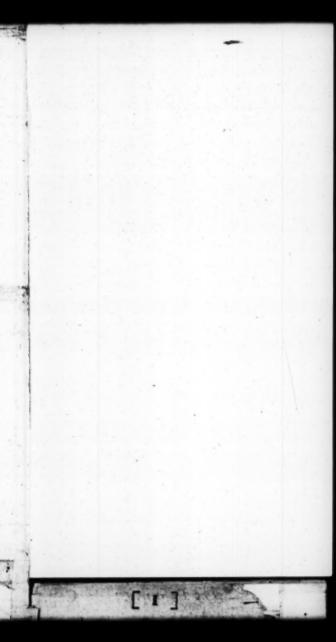
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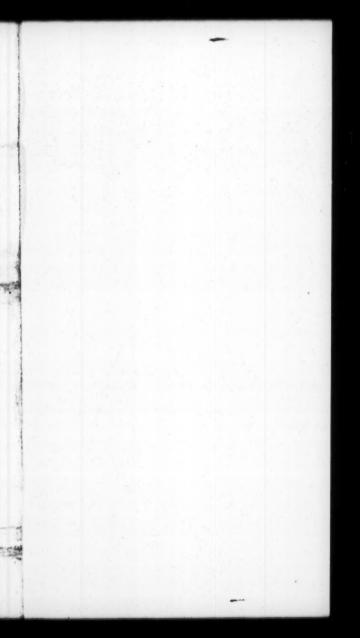
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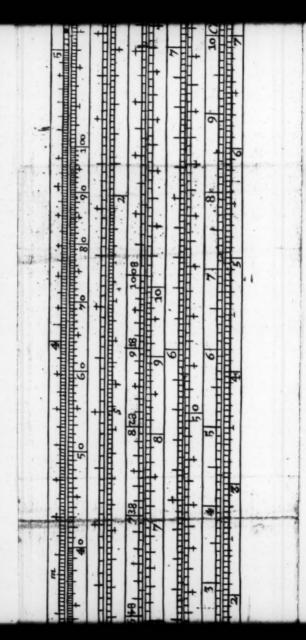


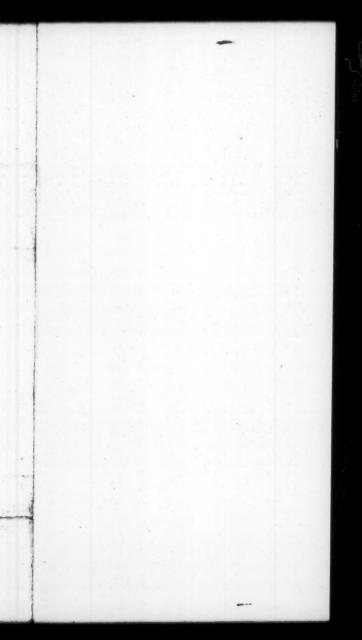
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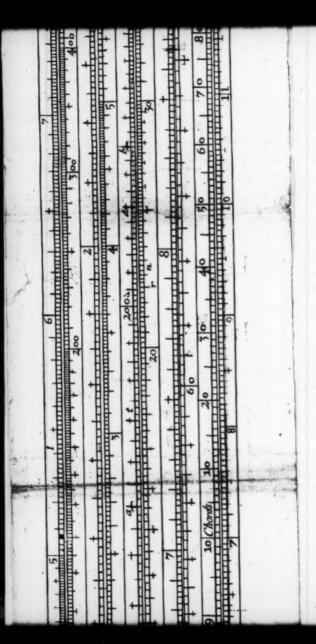


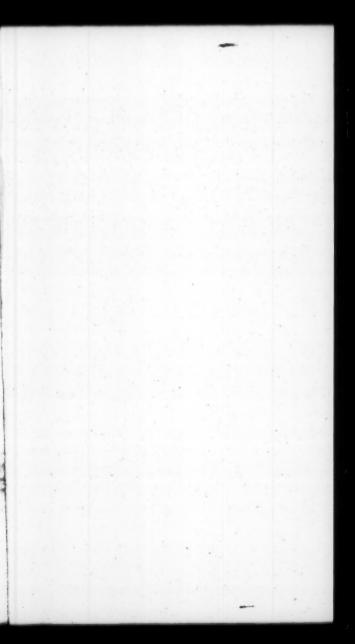
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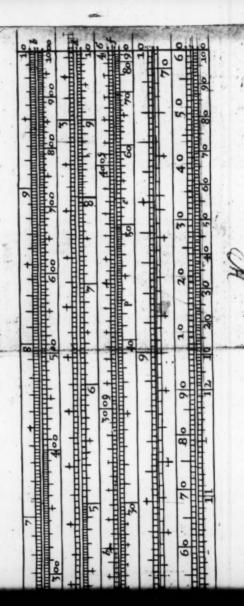


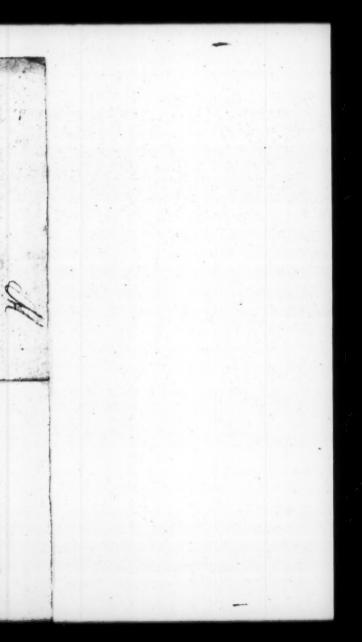














THE USE OF THE

Rule of Proportion in Arithmetique and Geometrie.

CAP. I.

The Description of the Scales projected upon the Rule of Proportion.

Pon the five Lines of the Rule of proportion, there are ten several Scales projected, viz. two upon each common or maddle Line, the one having the Divisions there of shoring downwards, the other to the first two Scales meet upo the

middle or common Line a, b, the next two upon the Line c. d. &c.

The uppermost or first Scale of the Rule n a single Line of Numbers, first divided into nine unequal parts, called Frimes, and diffinguished by the Figures, 1.2.3.4.5.6.7.8.9. And then, each of those Primes, subdivided into ten other Parts (according to the same Reason) called Tenths: And again, cach of those Tenths subdivided, or at least supposed to be subdivided into ten other Parts, as the length of

Rule will admit: For Example, upon the Scheme of our Rule (hereunto annexed) which is supposed to be about two foot and three inches long between the end-lines in the four first Primes (viz., between the Figures 1 and 5) each Tenth is really subdivided into ten Parts; but in the rest of the Primes (viz. between the Figure 5, and the end of that Scale) each Tenth is divided but into five Parts; and therefore each of those five Parts ought to be effeemed to have the value of 2; and the faid tenth parts of those Tenths are hereafter called Centesmes: Lastly. each of those Centesmes is also supposed to be subdivided into ten leffer Parts, which are hereafter called Millains: By all which you may observe, that the longer the Rule is, the more small Divisions it will admit, and the shorter it is, the fewer.

The second Scale is another Line of Numbers thrice repeated: This Scale shoots upwards upon the Common Line a, b, and being of a lesser Volume than the former, must in some Parts thereof content it self with less Divisions, viz. from the Figure of 5 to the end of that Scale the Tenths are only divided into two Parts, and therefore each of those two Parts ought to retain the value of five: All the three Parts of this Scale being taken together, are hereafter (for distinction sake) called the Little Line of Numbers, and are in their use distinguished by the surfly are also of singular use for the ready discovery of the Cube-root, and for the resolution of other necessary operations, as shall be shewed hereafter.

The third Scale is the first Scale repeated, taking his beginning from the middle of the Rule, and being broken off at the upper end thereof, is afterwards continued from the lower end of the same to the place where it first began. This Scale abuts downwards upon the Common Line c, d; and the first and this being taken together are hereafter called the Great Line of Numbers,

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whereof the first Scale is called the first Part, and this the fecond.

The fourth Scale is another Line of Numbers twice repeated: This Scale shoots upwards upon the Common Line c, d, and being intirely taken together, is hereafter called the Mean Line of Numbers: It confifteth also of two Parts, diftinguished by first and fecond, as they lye in order; and is of necessary use for the finding of the Square-root, and of

mean Proportions, as shall appear hereafter.

The fifth Scale is a Line of Tangents; This Scale abuts downwards upon the common Line e, f, and doth first contain the Artificial Tangents of the Quadrant from o. degr. 35. min. to 45. degr. at the upper end of that Scale, and fo if the Rule would permit, should they be continued forward to 89. degr. 25.min.but because the Divisions of that Scale being inverted, will fall out to be the same with the former, they are to be noted and accounted backwards from 45. degr. at the upper end of that Scale to 89. degr. 25. min. at the lower end of the same; each degree thereof being fubdivided into fix Parts, and each of those fix Parts supposed to contain ten minutes.

The fixth Scale is a Line of Sines: Upon this Scale shooting upwards upon the Common Line e, f, are described the Artificial Sines of the Quadrant from o. degr. 35. min. to 90. degr. at the upper end of that Scale, each degree (upon our Rule) from o. degr. 35. min. to 30. degr. being subdivided into fix Parts. each Part representing ten minutes, as those of the Tangents; but from 30. degr. to 50. only into four Parts, each Part containing 15 minutes; from 50 to 70, into two Parts, each Part comprehending 30 minutes; from 70 to 85, into eaven degrees; and laftly, from 85 . degr. to 90, not divided at all, but supposed to be divided into five Parts, reprefenting those five last degrees of the Quadrant. B 2

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The seventh Scale shooting downwards, is the whole Rule divided into 1000 equal Parts; It is hereafter called the Scale of equal Parts, and is of use for the Construction and Fabrick of the Great Line of Numbers.

The eighth Scale shooting upwards, is a Scale of 70 degr. II min. of the Quadrant described according to Murcator and Mr. Wright's Projection: It is hereafter called the Scale of Latitudes, and is to be used together with the Scale of equal Parts; and both of these taken together, are usually called the Meridian Line, and are of excellent use in Navigation, as shall be declared hereafter.

The ninth is the Scale of Inch-measure, viz. two foot thereof divided into 24 inches, and each inch into ten lesser Parts, counted both forwards and back-

wards, after the ufual manner!

The tenth and last Scale consists of three several kinds, viz. a Gage Line, a Line of Cords, and a Scale of Footmeasure: The first of these being signed by the Letter G, is nothing else but seven inches divided into ten equal Parts, and those subdivided into ten lesser Parts, and is hereafter to be used for the ready discovery of the equated Diameter (and so by consequent of the Content) of any Wine, Beer, or Oyl Veffel: The next marked by the Letter C, is an ordinary. Line of Cords, already fufficiently known, and of frequent use amongst Artists; the third and last, marked by the Letter F, is the Scale of Foot-measure being nothing else but a foot first divided into ten Parts, and those subdivided into ten leffer Parts, and to (by confequent) the whole foot supposed to be thereby divided into 1000 Parts.

At the end of these two Scales there is another double Scale placed, containing in length three inches French, whereof the uppermost shooting downwards, is a Scale divided into 60 Parts, and that shooting upwards into 100 Parts: The use of

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these two Scales is for the ready reduction of Sexagenary minutes to Decimals, and of Decimal minutes to Sexagenaries, as shall appear hereafter.

CAP. II.

The Construction and Fabrick of the Lines described upon the Rule of Proportion.

To describe the Line of Numbers, having prepared a Rule of Silver, Brass, or Wood, (of what length you please) and caused it to be ruled according to the Pattern hereunto annexed, and also a Scale of 1000 equal Parts to be drawn, equal in length to your intended Line of Numbers, repair to the Table of Logarithms, and therein observing the first four Figures of the Logarithm of 101, beside the Index or Characteristick (viz. 0043) take with your Compasses the distance from the beginning of the Said Scale of equal Parts to the Said 43 Parts; This done, if you apply that extent of the Compasses upwards, from the beginning of the Line of Numbers, which you intend to make, the moveable Point of the Compasses, will fall upon the first Cenrefine of that Line: In like manner by the first four Figures of the Logarithm of 102, besides the Index (viz. 0086) you may mark the fecond Centeline of the same Line, and so consequently all the rest in their order.

Example, If it were propounded to make a Line of Numbers equal to that of the first Scale, let there be a Scale of equal Parts made, equal in length to

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Cap.II.

that Line, such as the seventh Scale before described happens to be: then extending your Compasses from the beginning of that Scale of equal Parts to 0043, viz. to the Point a, apply that extent from the beginning of your Intended Line of Numbers; For, that done, the moveable Point of the Compasses will fall upon the first Centesm of that Line, viz. at the Point e: In like manner, the extent from the beginning of the Scale of equal Parts to 0086, viz. to the Point c, will mark out upon the intended Line of Numbers the Point b, representing the second Centesm of that Line, and so consequently the rest in order.

2. The Line of Tangents is framed much after the time manner; For, having before prepared a Scale of equal Parts futable to that Line, (viz. confifting of haif the length of the whole Line) Repair unto the Toble of Artificial Sines and Tangents, and therein finding the Artificial Tangent of o. degr. 40. min. if (rejecting the Characteristick or first Figure thereof) you take off with your Compasses upon your foresaid sutable Scale of equal Parts (as before) the four first Figures of the same Tangent (viz. 0658) that extent being applied upwards from the beginning of the Line of Tangents, will cause the moveable Point of the Compasses to fall up in the Division, representing o. degr. 40.min. In like manner the extent of 1627 (the second, third, fourth, and fish Figures of the Tangent of o. degr. 50. min.) will guide to mark out the same o. degr. 50 min. upon the same Line : And so proceeding you may readily describe all the

rest, as they follow in order.

3. The Line of Sines may be drawn in all Points, as the Line of Tangents, if you use the second, third, fourth and fifth Figures of the Artificial Sines, as you are before directed to use those of the Tangents. And here note, that the Line before called the Mean Line of Numbers, and these Lines of Tangents and Sines are all of them framed by one and the same

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ime ale, Scale, and are also hereafter to be used together in the resolution of *Plain Triangles*, the Scale of equal Parts or *Radius*, by which they are made, being in each of them twice repeated.

4. The Meridian Line being framed by the ordinary Table of Meridianal Degrees, and the making of the Line of Cords being obvious to every mean Practitioner in the Mathematicks, I shall not need to trouble you with their Construction. The other Scales also, which consist of equal Parts, will not need any farther description.

CAP. III.

Numeration upon the Rule of Proportion.

PROBL. 1.

A whole Number being given, to find the Point where the same is represented upon the Line of Numbers.

Ind amongst the Figures, by which the Primes are diftinguished, the first Figure of the Number given, and for the second Figure there f count from the beginning of the Prime, unto which the first Figure directs you, so many Tenths as that Figure bath Unites; Then for the third Figure count from the last Tenth so many Centesms as that B 4 third Figure hath Unites: And so likewise for the fourth Figure count from the last Centesme so many Millains as the same fourth Figure hath Unites: This done, you shall all lest fall upon the Point where the Number propounded

is represented upon the Line of Numbers.

Example, The Number given being 1728, the first Figure thereof (viz. 1.) leads me unto the first Prime, designed by the Figure 1, within which Prime counting seven Tenths for the second Figure, and from the seventh Tenth two Centesmes, for the third Figure, and from the second Centesme eight Milains for the fourth Figure; at last I find the Number given to be represented upon the first Part of the Great Line of Numbers at the Point h: So likewise is the Number 27 found at the Point k, the Number 542 at the Point I, and 3345 at the Point m, &c.

From hence follow these Corollaries:

1. The Figure which any Number given hath towards the right hand, belides the first four Figures towards the left hand, are not expressed upon the Rule: And therefore if the Number given were 172845, it would be likewise represented at the Point h: Howbeit, that uncertainty causeth no inconvenience in the use of the Rule, as shall more plainly appear hereafter.

2. The Figures by which the Primes are distinguished (in reference to one and the same Number) retain always

one and the Same value.

Example, In fearching the Number 1728, conceiving the Figure prefixed at the beginning of the first Prime (viz. 1.) to have the value of Thousands, the Figure prefixed before the second Prime (viz. 2.) ought also to be esteemed to have the value of Thousands, and so of the rest in their order: for, according to the same reason that h represents 1728, the Point n will represent 2000, the Point p 3000, &c.

3. The Numbers, which have only the simple value of Thites at 1.2.3, 4. &c. and these which after the first Figure

Figure have nothing but Cyphers, as 10.100.1000.20.200. 2000. Crc. are all represented at the Same Points.

So 1.10.100.1000. c.may be all represented at the beginning or end of the Line 2. 20, 200, 2000. Oc. at the beginning of the second Prime: 3. 30. 300. 3000. &c. at the beginning of the third Prime, &c.

4. The Numbers, which being composed of three Figures have a Cypher in the middle, are found between the beginning of the Prime, unto which they belong, and the first Tenth of the Same Prime.

So 405 beginning by the Figure 4, (and therefore to be fought for in the fourth Prime) is represented at

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5. The Numbers, which being compifed of four Figures, have now Cyphers in the middle, are represented betweent the beginning of the Prime, unto which they belong, and the first Centesme of the Same Prime : So 1005 is found at the Point q.

6. When the Line of Numbers is repeated, and for that cause consisteth of several Parts; the first Part there f is in value a degree less than the second, and the second a de-

greelest than the third, &c.

So upon the Mean Line of Numbers, if you corceive to at the upper end thereof to represent 100, the Figure 1 in the middle (or which is all one, at the beginning of the fecond Part) will represent 10, and I at the lower end of that Line (or which is all one, at the beginning of the first Part) will represent 1: But if 10 at the upper end thereof shall be conceived to bear but the value of 10, the Figure 1 in the middle shall have the value of one, and one at the lower end the value of 10, and 2 the value of 200 erc. In like manner, if 10 at the upper end repr. Int I . the Figure I in the middle must represent and I at the lower end Total & C.

PROB.

PROBL. 2.

To find a Fraction or broken Number upon the Line of Numbers.

He Fractions, which are to be found upon the Line of Numbers, ought always to be Decimals, viz. ought always to have for their Denominators the Figure 1, with nothing but Cyphers towards the right hand, such as are 125 25 or the like, which may otherwise be written thus, 125.25,5,75, and are equivalent to 1 1 2 and 3: And therefore if the Fractions propounded be not Decimals, they ought to be reduced to fuch: For, that done, they may be discovered in all Points as whole Numbers are found out upon the Line, which may be plainly understood by the Examples produced in the fixt Corollary of the last Problem.

PROBL. III.

To find a Mixt Number upon the Line of Numbers.

Irst find by the first Problem aforegoing the Point representing the whole Parts of the Number given, and then afterwards the Fraction or broken Parts there f in the Ranks that follow.

Example, a Line that hath the length of 17 foot and 28 of a foot (which may more conveniently

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be written thus, 17, 28) being propounded; first, I find the whole Parts thereof, viz. 17) represented at the Point r, and after counting two Centesins, and then eight Millains, at last I find the Number given to be represented at the Point h. In like manner if the Number propounded were 172. 8, or 1.728, it would be still represented at the same Point.

PROBL. IV.

Any Point of the Line of Numbers being assigned, to find the Figures represented at the same Point.

Ake the Figure prefixed at the beginning of the Prime, within which the Point is propounded, for the first of the Figures required; then shall the second Figure required be composed of so many Unites as there are Tenth's intercepted between the beginning of the same Prime and the Point given. In like manner shall the third Figure required have so many Unites as there are Centesms comprehended between the last of those Tenths and the said Point: And so likewise shall the fourth Figure consist of so many Unites as there are Millains between the last Centesm and the Point given.

Example, If the Point h were propounded, because that Point is situate within the Prime, before which the Figure 1 is prefixed, I take the Figure 1 for the first of those required; and then inding seven Tenths betwirt the beginning of that Prime and the Point given, I set down 7 for the second: And to proceeding and finding two Centesius betwirt the last Tenth and the Gaid Point; I take 2 for the third Figure: And lastly, conceiving eight Millains to be comprehended between the last Cen-

tesme and the Point given, I take 8 for the fourth Figure required: This done, I conclude, that the Figures represented at the Point propounded, are 1728. In the manner the Point q being given, I take I for the first Figure; but here because I find no Tenths betwitt the beginning of that Prime and the Point given, I write a Cypher in the second place; and there also finding no Centesines, I write also a Cypher in the third place; And then at last sinding the Point propounded in the middle of a Centesine (which is supposed to be divided into ten Millains) I annex in the fourth place; This done, the Figures represented at the Point given will be found 1005.

PROBL. 5.

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An Ark or Angle being propounded to find upon the Rule of Proportion the Point which represents the Tangent of the same Ark or Angle.

IF the Ark or the measure of the Angle exceeds not 45 degrees, search the degrees of that Arke or Angle upon the Line of Tangents, mounting upwards from the lower end of that Line towards the upper end of the same.

So the Tangent of an Ark or Angle, which confifts of 15 degrees, is represented at the Point 4: of

25 degrees at the Point h, &c.

But if the Ark or measure of the Angle exceeds 45 degrees, look the degrees thereof, descending downswards from the upper end of the Line sowards the loveer end of the same. So the Tangent of 65 degrees is found at

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the Point b, of 75 degrees at the Point a, &c.

And if the Ark or Angle propounded (besides the whole degrees) is also composed of certain minutes, find first the whole degrees, and after that, bet wixt the last degree found, and the next that follows, take so many of the Parts which may amount to the minutes given accounting each of the Parts contained betwirt the two degrees for ten minutes: So the Tangent of 22 degr. 45 min. is found at the Point d, and the Tangent of 72 degr. 45 min. at the Point a. And therefore e converse, if the Points d and t were given upon this Line, the degrees and minutes represented by them, would be 22 degr. 45 min. and 72 degr. 45 min. &c.

PROBL. 6.

An Ark or Angle being propounded, to find upon the Rule of Proportion the Point, which represents the Sine of the same Ark or Angle.

I Ind upon the Line of Sines the degrees of the Ark or Angle given, and you have your defire: So the Sine of the Ark or Angle of 22 degr. is reprefented at the Point r.

But if the Ark or Angle given have also minutes annexed, first search the whole degrees given, and then between that degree found and the next that follows, take so many Parts as you have minutes propounded, conceiving the distance betwixt each degree, and the next that follows to comprehend 60 minutes.

So the Sine of 22 degr. 45 min. is found at the Point w; of 42 degr. 50 min. at the Point q; of 52 degr. 45 min. at the Point c, Gre. And therefore here

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also e converso, if the Points u, q, and e were assigned upon this Line, the degrees and minutes represented by them would be 22 degr. 45 min. 42 degr. 50 min. and 52 degr. 45 min. &c.

CAP. IV.

The use of the Rule of Proportion in Arithmetick.

N Arithmetick there are three several forts of Proportion, Arithmetical, Geometrical, and Mufical. Arithmetical, when divers Numbers being compared together retain amongst themselves equal differences, as thele, 2. 4. 6. 8. &c. And this is either continued, as in the Numbers before produced, or in thefe, 3. 6. 9. 12. 15, &c. which is alfo called Arithmetical Progression, or a Rank of Numbers Arithmetically proportional; or discontinued, as in thefe, 2. 4. 10. 12, or the like. Gemetrical Proportion is, when divers Numbers being compared together differ amongst themselves according to the sime rate or reason, as these, 2. 4. 8. 16. er. For here, as 2 is half 4, fo is 4 half 8, and 8 half 16: this is likewife either continued, as in those before propounded, or in thefe, 1, 3, 9, 27, 81. Ge. or the like, which is also called Geometrical Progression, or a Rank of Numbers Geometrically proportional: Or discontinued, as in thefe, 2, 4, 16, 32, 2 for as 4 is double 2 , fo is 32 double 16, but to is not 16 being compared with 4. Musical Proportion is that which doch as it were proceed from both the former, as when three Numbers or Terms being propounded, the first bears the same Proportion to the third, that the differences betwix

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betwixt the first and the second bears to the difference betwixt the second and third, as in these, 3.
4. 6, for here, as 3 is half 6, so is 1, the difference betwixt 3 and 4, to 2, the difference betwixt 4 and 6. So likewise 2. 3. 6, and 10. 16. 40. are said to be Numbers Musically proportional: For, in the first of these two last Examples, as 2 is to 6, so is 1 to 3; And in the others, as 10 is to 40, so is 6 to 24. Thus have I here thought sit briefly to remember the Reader of the several kinds of Proportion, which he doth usually sind in the Writings of those that treat of Arithmetick; to the end that the Problems which follow both in Arithmetick and Geometry may be the better understood.

PROBL. I.

Two Numbers being given, to find a third Geometrically proportional unto them, and to three a fourth, and to four a fifth, &c.

E Xtend the Compasses upon the Line of Numbers from one of the Numbers given to the other; this done, if you apply the same extent (upwards or downwards) from either of the Numbers propounded, the moveable Point of the Compasses will fall upon the third proportional required: And so the same extent being applyed the same way from the third, the moveable Point of the Compasses will fall upon the fourth proportional, and from the fourth upon the fifth, &c.

Example, Let it be propounded to find a third proportional to these two Numbers 2 and 4, which may bear the same Proportion to 4, that 4 bears

to 2; First, I Extend the Compasses upon the first Part of the Mean Line of Numbers from 2 to 4 : this done, if I apply that extent outright from 4 upwards, the moveable Point of the Compasses will fall upon 8 the third Proportional required ; and being applied the same way from 8, the movable Point will rest upon 16, the fourth Proportional: and from 16 to 32, the fifth; and from 32 to 64. the fixth Proportional. But now if you would yet continue the Progression farther, and so find the next Proportional to 64 (because the movable Point in that case will fall beyond the Line) apply that extent the same way from 64 in the first Part of that Line: which done, the movable Point of the Compaffes will then fall upon 128, the feventh Proportional: and so proceeding farther you may find 256, the eighth 3512, the ninth, erc.

Contrariwife, if it were required to find a third Proportional to the same Number 2 and 4, which may bear the same proportion to 2, that 2 bears to 4; extend the Compasses upon the second Part of the Mean. Line of Numbers from 4 to 2 downwards; this done, if you apply that extent from 2 the same way (viz. downwards) the movable Point will fall upon 1, the third Proportiona required; And from 1 upon Try or .5, by the last Corallary of the third Chapter, and from .5 to .25, by the same

Corallary, &c.

In like manner, if the two Numbers given were 10 and 9, the Compasses being extended downwards from 10 at the upper end of the same Line of Numbers to 9, and that extent applied from 9 the same way, the movable Point of the Compasses will rest upon 8.1, the third Proportional (for the given Numbers being 10 and 9, common sense tells me that it cannot be 81, and therefore ought to be \$.1) and from 8.1 the movable Point will fall up-

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on 7.29, the fourth Proportional, &c. So likewise if the Numbers propounded were 1 and 9, conceiving 10 at the upper end of the Line to repretent 1, extend the Compasses from thence to 9, which extent being applied downwards from 9, will cause the movable Point of the Compasses to fall upon 81, the third Proportional, and from 81 upon 729, the fourth Proportional, &c. And therefore note hence, that 1 at the beginning, 1 in the middle, and 10 at the end of the Line, are all arbitrary Points, and may each of them represent sometimes 1, sometimes 10, sometimes 100, sometimes 1000, &c. as the terms by which you are to work, shall require, according to the third Corollary of the third Chapter.

Nevertheless neither do the Examples before produced, nor those, which shall follow in the ensuing Problems at all cross that which hath been formerly taught in the second Corollary of the third Chapter: For, in the last Example, the end of the Line in regard of the first term given (viz. 1) hath the single value of an Unite; but in respect of the second term 9 is challengeth the value of 10; and in reference to the third Number 81, the value of

100, Oc.

Lattly, if the Numbers given were 10 and 12, the third Proportional upwards would be 14.4, the fourth 17.28, &c. and the Number 1 and 12 being propounded, the third Proportional upwards (as be-

fore) will be 1443, the fourth 1728, &c.

The like Operations may be also performed (and that much more exactly) upon the great Line of Numbers: For Example, I and 4 being given, I defire to know a third, a fourth, a fifth, erc. Geometrically Proportional: To perform this, extend the Compasses upon that Line across from I at the beginning of the second Part thereof unto 4 upon the fift part of the same; which done, that extent be-

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ing applied the same way, (viz. upwards and acros) will reach from 4 upon the first Part, unto 16 upon the sicond, and from thence to 64 upon the first Part again, &c.

PROBL. 2.

One Number being given to be multiplied by another Number given, to find the Product.

E Xtend the Compasses upon the Line of Numbers from I unto the Multiplicator; This done, if you apply that extent the same way from the Multiplicand, the moveable Point of the Composses will fail upon the

Product required.

1. Example, Let the Multiplicator given be 25, and the Multiplicand 30: Here if you extend the Compasses upon any of the Lines of Number from 1 unto 25, and then apply that extent the same way from 30, the moveable Point of the Compasses will fall upon 750, the Product required. So 1. 728, and 25. 6 being propounded to be multiplied, the Pro-

duct will be found 44. 2.

2. Example, The two Numbers given being 45 and 25, I extend the Compasses upon the second Part of the Mean Line of Numbers from 1 to 25; Then (because, if I apply that extent the same way from 45 upon the same Part of that Line, the moveable Point will fall beyond the Line) I apply the same extent the same way from 45 in the first Part thereof; which done, the movable Point will fall upon 1125, the Product desired: So the two Numbers given, being 1.728, and 64.5, the Product required will be 111.4.

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3. Example, If 75 and 35 were given to be multiplied, the Compasses ought to be extended downwards from 1 to 75, in the first Part of the Mean Line of Numbers, or (which is all one) from 10 at the upper end of that Line to 75; for, that extent being applied the same way from 35, will cause the movable Point of the Compasses to fall upon 2625, the Product required.

4. Example, If it were required to find the Content of a piece of Ground 8.75 Perches long, and 6.45 broad; because this question is resolved by multiplying the length by the breadth, I extend the Compasses from 10. at the top of the Line to 8.75; then applying that extent the same way from 6.45, the movable Point will fall upon 56.4, the Content required, viz. 56 Perches and \$\frac{4}{5}\$ or .4 of a Perch.

And here you may observe, that these last Examples, and those that are like unto them, may likewise be performed in working upwards; But in such cases to shan too great an extent of the Compasses, it is better to begin the Operation from to at the top of the Line, and to to descend downwards according to the Instructions before delivered: For, take this for a General Rule, once for all, that All Operations, which are wrought upon the Rule of Proportion, are best performed, when the legs of the Compasses have the least extension.

Again, because this Problem of Multiplication, as also (for the most part) all the rest that follow, are resolved by the finding out of a fourth Number Geometrically proportional to three other Numbers given, we will therefore here insert this other Advertisement: Whensoever question is made of finding a fourth proportional to three such Numbers given, for the better conveniency of working upon the Rule, the order of the second and third terms may be changed, so that always care be taken, that the first

first Number may still retain the first place: For Example, you may say, as 1 is to 25, so is 30 to 750; or as 1 is to 30, so is 25 to 750. And this Rule is diligently to be observed in Multiplication, Division, the Rule of three direct, the resolution of the Plane and Spherical Triangles, and generally in all Questions of such like Proportions; to the end that in working upon the Rule of Proportion we may always avoid too great an exension of the Compasses, and by that means perform the Work the more exactiv.

Lastly, here observe, that Multiplication, and all other Questions hereafter produced, which may be wrought upon the Mean Line of Numbers, may likewise be performed upon the Great Line of Numbers (and that much more exactly) by working either outright or across, as the Questions propounded shall require; which (I well hope) I may hereafter leave to the discretion of the ingenious Reader to discover, without any further instruction, they being (indeed) but one and the same Instrument represented

in differing postures.

PROBL. 3.

A Number being propounded to be divided by another Number, to find the Quotient.

E Xtend the Compasses upon the line of Numbers from the Divisor to 1; This done, if you apply that extent the same way from the Dividend, the movable Point will fall upon the Number of the Quotient.

I. Example, Let 750 be the Number given to be

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divided by 25, the Divifor: I extend the Compaffes downwards from 25 to 1; then applying that extent the same way from 750, at last the movable Point will fall upon 30, the Quotient required.

2. The Number 1125 being given to be divided by 25 : I extend the Compaffes downwards from 25 to I, then applying that extent the same way from 1125, the movable Point will fall upon 45, the Quotient required. The same Quotient will also be found, if changing the terms you first extend the Compasses from 25 to 1125, and then apply that extent from 1; for fo also shall the movable Point fall upon 45. as before; according to the observation made in the last Problem: In like manner 111.4 being propounded, to be divided by 1. 728, the Quotient will be found 64.5.

3. The Number 2625 being propounded to be divided by 75; extend the Compasses upwards from 75; in the first Part of the Mean Line of Numbers to 1, or (which is all one) from 75 in the fecond Part thereof to 10 at the top of the Line; This done, if you apply that extent the same way from 2625, the movable Point will from thence reach to 35, the Quotient required: So likewife 56. 4 being given to be divided by 8.75, the Quotient

will be 6.45.

Now to discover of how many Figures any Quotient ought to confift, it will be necessary to observe how many times the Divifor may be written under the Dividend according to the Rules of Division; for, of fo many Figures shall the Quotient be composed: for Example, 12231 being given to be divided by 27; because the Divisor 27 may (according to the Rules of Division) be written three times under the Dividend 12231 (as may appear by this Example) I say, that the Quotient, 12231 which is produced by the Division of 27 . .

12231 by 27 confifts of three Figures

For

For, having extended the Compaffes downwards in the fecond Part of the Mean Line of Numbers from 27 (the Divisior) to 12231 (the Dividend) and applied that extent the same way from 1, the moveable Point will fall in the first Part upon 453, the Quotient of 12231 divided by 27.

PROBL. 4.

To three Numbers given to find a fourth in a direct Proportion.

E Xtend the Compasses from the first Number or Term given, unto the second, which done, that extent being applied the same way from the third Term, will cause the movable Point to fall upon the fourth

Term required.

Example, If the circumference of a Circle, whose Diameter is 7, be 22; what circumference will a Circle have, whose Diameter is 14? Extend the Compasses upwards upon the Mean Line of Numbers from seven in the first Part thereof, unto 14 in the second; This done, that extent being applied the same way from 22, will make the movable Point rest upon 44, the circumference required.

Or otherwise downwards; The circumference of a Circle being 22, and the Diameter thereof 7, how much shall the Diameter of a Circle be, whose circumference is 44? Extend the Compasses downwards from 22 in the second Part, to 7 in the first; which done, that extent being applied the same way from 44, will reach to 14, the Diameter sought

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PROBL. 5.

To three Numbers given, to find a fourth in an inversed Proportion.

E Xtend the Compasses upon the Line of Numbers from the first of the Numbers given to the second, having both the same Denomination; this done, if that extent be applied quite backwards from the third given Number, the movable Point will fall upon the

fourth Number you look for.

Example, If 60 Pioners can make a Trench of a certain length and breadth in 45 hours, how long will it be before 40 men can make such another? Extend the Compasses from 60 to 40 (those Terms having both the same Denomination, viz. of men.) This done, that extent being applied backwards from 45, will reach to 67. 5, the fourth Number you look for; I conclude therefore that 40 men will perform as much in 67 hours and an half, as 60 men will do in 45 hours.

PROBL. 6.

To three Numbers given, to find a fourth in a double Proportion.

The use of this Problem appears chiefly in Proportions of Lines to Superficies, or of Superficies to Lines.

Now if the Denomination of the first and second terms be of Lines, Extend the Compasses upon the Line of Numbers, from the first term to the second; this done. that extent being applied twice the same way from the third term will cause the movable Point to fall upon the

fourth term required.

Example, If the Content of a Circle whose Diameter is 14 inches, be 154, what will the Content of a Circle be, whose Diameter is 28? Here 14 and 28 having the same Denomination (viz. of Lines) I extend the Compasses from 14 to 28; then applying that extent the same way from 154, the movable Point will first fall upon 308, and from hence upon 616, the Content defired.

But if the first two terms have the Denomination of areas or Contents, and the quasitum be a Line, this is the Rule: Extend the Compasses upon the Mean Line of Numbers from the first term to the second; this done, that extent being applied the same way upon the Great Line of Numbers from the third term, will cause the movable Point to fall upon the fourth term required.

Example, If the Diameter of a Circle, whose area is 154, be 14; what Diameter will a Circle have, whose area is 616? Extend the Compasses upon thee Mean Line of Numbers from 154 to 616; which done, that extent being applied the same way upon the Great Line of Numbers from 14, will reach to 28, the Diameter required.

PROBL. 7.

To three Numbers given, to find a fourth in a tripled Proportion.

He use of this Problem appears in the proportion of Lines to Solids, & contra.

If

If therefore the first and second Terms have the denomination of Lines, Extend the Compasses upon the Line of Numbers from the first Term to the second; this done, and that extent applied three times the same way from the third Term; will cause the movable Point at last to fall upon the fourth Term required.

If an Iron Bullet, whose Diameter is 4 inches, weighing 9 pounds, what is the weight of another Iron Bullet, whose Diameter is 8 inches? Extend the Compasses from 4 to 8! which done, and that extent applied the same way three times from 9, the movable Point will first fall upon 18, then from 18 upon 36, and at last from 36 upon 72 the weight required.

But if the first two Terms be weights or contents of Solids, and a Line is sought for: Extend the Compasses upon the Little Line of Numbers from the first Term to the second; This done; and that extent applied the same way upon the Great Line of Numbers from the third term will cause the movable Point of the Compasses to fall upon the sourth Term required.

If the fide of a Cube weighing 72 pounds be 8 inches, how many inches is the fide of a Cube that weighs 9 pound? Extend the Compasses downwards upon the Little Line of Numbers from 72 to 9; that done, and the same extent applied the same way upon the Great Line of Numbers from 8, will cause the movable Point to fall upon 4, the fide required.

PROBL. 8.

Betwixt two Numbers given to find a Mean Arithmetically Proportional.

This Problem may be performed without the help of the Rule of Proportion: Nevertheless, because

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because it conduceth to the resolution of the next infuing Problem, I insert it in this place, and give this Sur Rule for it:

Add half the difference of the given Terms to the lef-Profer of them: for, that aggregate is the Arithmetical Mean an

required.

Example, Let 10 and 40 be the Terms given: here, if you substract the one out of the other, their difference will be found 30. whose half (15) being added to 10, the lesser Term, their sum (25) is the Arithmetical Mean you look for.

PROBL. 9.

Betwixt two Numbers given, to find a Mean Musically proportional.

Boeius (Lib. 2. Arith. cap. 38.) hath this Rule for it: Differentiam terminorum in minorem terminum multiplica, & post junge terminos, & juxta eum, qui inde confestus est, commiste illum numerum, qui ex differentis & termino minore productus est, cuius cum latitudinem invenera, addas eam minori termino, & quod inde coligitur medium terminum pones. Multiply the difference of the Terms by the lesser Term, and add likewise the same Terms tegether: this done, if you divide that Product by the Sum of the Terms, and to the Quotient thereof add the lesser Term that last Sum is the Musical Mean desired.

Or thorter thus:

Divide the Product of the given Term by their Sum: for, this done, the Quotient doubled is the mean required. So the Numbers given being 6 and 12, I say 12 multiplyed

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tin-tiplyed by 6 make 72, which divided by 18 the this Sum of 12 and 6) leaves 4 in the Quotient, whose double (8) is the Musical Mean you look for. This elef-Problem therefore may be performed by the second and third aforegoing! or yet otherwise thus:

Find the Arithmetical Mean between the Number

ven: given and then the Analogy will be this.

As the Arithmetical Mean found in to the greater Extreme: for the leffer Extreme to the Mufual Mean required.

Example, 10 and 40 being propounded, the Arithmetical Mean betwixt them (by the last Problem) is 25: I say then, As 25 is to 40, so is 10 to 16, the Musical Mean desired: the Term therefore here sought for may be discovered by the fourth Pro-

blem aforegoing.

And here (I conceive) it will not be amiss to observe, that by this last Rule, having any two Numbers propounded, you may interject two other Numbers betwixt them! in such fort that they four being in feveral relations compared one with another, may contain in them all the three Proportions abovementioned, which kind of Harmony Boetius (lib. 2. cap. selt.) calls Maxima & perfecta simple. nia: So in the Numbers before mentioned to, 16, 25, and 40; if you compare 10,25, and 40 together, there: shall you find Arithmetical Proportion if 10, 16, and 40 together, there Harmony, or Musical Proportion, if all of them together, there have you Geometrical Proportion discontinued: For as 10 to 16, fo 25 to 40. And this is that Harmony which the fame Boerius (in the fame place) affirment to have Magnam vim in Musici modulamini temperamentin , & in freculatione naturalium questionum ? Great force in the composure of Musick, and in the discovery of the secrets of Nature: And therefore be also averreth in another place (viz. lib. I. cap. 2.) that the reason of Numbers was the chiefest Rule according

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ding to which Almighty God framed the World: According to that testified of the Wildom of God (in the Wildom of Sol. cap. 11. v. 20.) Thou hast ordered all things in Measure; and Number; and Weight. The Statists also and Politicians fetch much from these three Proportions for the regular direction of a well governed Commonwealth, as may be easily collected out of their Writings, and is learnedly proved by Bedin in the last Chapter of his Commonwealth.

PROBL. 10.

Betwixt two Numbers given, to find a Mean Geometrically Proportional.

E Xtend the Composses upon the Mean Line of Numbers from one of the Numbers given to the other; this done; and the same extent applied upon the Great Line of Numbers from either of those Numbers towards the other; the movable Point will fall in the middle between them; viz. upon the Point representing the Mean Proportional required.

Example; 8 and 32 being propounded, the Mean Proportional between them will be found 16: For if I extend the Compaffes upon the Mean Line of Numbers, from 8 in the first part thereof to 32 in the second, and afterwards apply that extent upon the great Line of Numbers from 8 towards 32, the movable Point will fall upon 16, the Mean Proportional demanded; for as 8 is to 16 so is 16 to 32: so the Mean betwixt 6.4, and 14.4, is 9.6,

PROBL. 11.

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PROBL. II.

Betwixt two Numbers given to find two Means Geometrically Proportional.

E Xtend the Composses upon the Little Line of Numbers from one of the Numbers given to the other:
this done, and that extent applied upon the Great
Line of Numbers from either of those Numbers towards
the other; will cause the movable Point to fall first on the
third part of the distance between them; viz. upon the
Point representing one of the Mean Numbers required; and
being applied again the same way; will at last rest upon
the other Proportional you look for.

Example; Let 8 and 27 be the two Numbers between which two Mean Proportionals are defired. First, I extend the Compasses upon the Little Line of Numbers upwards from 8 to 27: then applying that extent twice upon the Great Line of Numbers from 8 towards 27, I find the movable Point to fall first upon 112, and then upon 118, which are the two Means you desire to know: for as 8 is to 12, so is

12 to 18, and 18 to 27.

PROBL. 12.

To find the Square-Root of any Nuntber under 100000.

The Extraction of Roots, which is accounted the hardest Lesson in Arithmetics, is performed by C 3 the

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he help of this Instrument with greatest ease and dexterity: for, whereas the Problems before premised, as also those that follow, cannot well be expedited without the joynt use of the Rule and Compasses together, these of the Extraction of the Squara and Cube Roots may be resolved only by Inspection without any trouble at all, or and of Compasses: so that a man either riding or going in haste may immediately read upon the Rule the Root of any Square or Cube Number propounded: which compendious way of Extraction cannot choose but prove to be of admirable use, especially in questions that concern Military Orders, as shall more plainly appear hereafter. Wherefore to extract the Square-Root proceed thus:

1. When the Figures of the Number given are even, viz. when the Number confists of two, four, or fix Figures, look the same Number in the first part of the Mean Line of Numbers: which done, just at the same Point shall you likewosfe find upon the Great Line of Numbers the Square

Root you look for.

Example, 264196 being propounded, the Square-Root thereof will be found \$14: for I find the Number 264196 represented in the first part of the Mean Line of Numbers at the Point x, and at the same Point upon the second part of the Great Line of Numbers I observe \$14, the Square-Root required.

2. When the Figures of the Number given are odd, vizone, three, or five, Scarch the Same Number in the Second part of the Mean Line of Numbers: which done, just at the Same Point upon the Great Line of Numbers shall

you find atfo the Square-Root demanded.

Example, 144 being propounded, I demand the Square-Yoot thereof: that Number I find to be repredented in the second part of the Mean Line of Numbers at the Point 3, and just there also upon the Great Line of Numbers I discover 12, which is the

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afe and the Square-Root of the Number propounded. So premi likewife is 144 the Square-Root of 20736.

PROBL. 13.

To extract the Cube-Root of any Number under 1000000000.

Hen the Number propounded confists of one, four, or leven bigures, find it in the first part of the kittle Line of Numbers: that done, at the same Point upon the first part of the Great Line of Numbers, you shall find the Cube-Root you look for.

Example. Let the Number given be 1728 whereof the Cube-Root is required: I find that Number
in the first part of the Little Line of Numbers at the
Point t, and at the same Point upon the Great Line
of Numbers I also discover 12, the Cube-Root desired: In like manner is 12,52 the Cube-Root of 1950,
and 144 the Cube-Root of 2985984.

2. When the Number given confifts of two, fave, or eight Figures., feareh it in the forend part of the Little Line of Numbers, and that proceeding as before, you shall have your define.

Example, If 14348907 were given, the Root thereof would be found 243 for, that Number being
found in the second part of the Little Line of Numbers at the Point #, just at the sume Point upon the
Great Line I also find 243, the Cube-Root required.

5. When the Number propounded confists of three flx, or nine Figures, look for it in the third part of the Little Line of Numbers: for so likewise at the same Point up in the Great Line will appear the Root required.

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So the Number 159220088 being found in the first part of the Little Line of Numbers at the Point 2., his Cube-Root is there likewise found upon the Grent Line of Numbers to be 542: And the Cube Root of 159220. is found to be 54.

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The order of finding out the Cube-Numbers upon the feveral parts of the Line may be fitly expressed by this Figure

CAP. V.

The Use of the Rule of Proportion in Geometry, viz.

In the Dimension,

1. Of Plain Triangles.

PROBL. 1.

The three Angles and one Side being known, to find the other two Sides.

TO refolve this Problem this is the Analogy.

As the Sine of the Angle opposed to the side known

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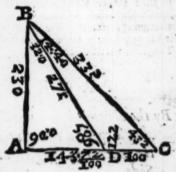
known is to the parts of the fame fide: so is the Angle opposed to one of the sides unknown, to the parts which measure that side: And therefore

Extend the Compasses across from the Sine of the Angle opposed to the side known; to the same side; found upon the Mean Line of Numbers: then applying that extent the same way from the Sine of the Angle eposed to ene of the sides required; the movable Point will fall upon

the parts which measure that required side.

Example In the Triangle C, B; D; let the Angle C be 43 degr. 20 min. the l Angle D 122 d and by confequent the Angle B (being the Complement of the two other Angles to 180 d. or two right Angles) 14 degr. 40 min. and let the fide D; C, being 100 paces represent the distance between the two stations D and C: I demand then the distance between C and B: Extend the Compasses across from 14 degr. 40 m. upon the Line of Sines to the middle of the Mean

Line of Numbers representing 100, then that extent being applied the same way from 122 d. upon the Line of Sines or (which is all one) from 58 degr. (for by the Rules of Trigonometry the Sine of an obtaile Angle and



that of his Complement to 180 is one and the same Line) will cause the movable Point to fall upon 135, and so many paces is the distance required: In like manner, the extent being applied the same way from 43 d. 20 m. upon the Line of Sines, the movable

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Point will fall upon 271, the parts of the fide D, B. kn Or otherwise, by changing the Terms of the A- fee

'nalogie, thus :

Extend the Compasses outright upon the Line of Sines from 14 d. 40 m. to 58 d. then applying that extent the same way upon the Line of Numbers from 100, the moveable Point will rest upon 335, the distance required: so likewise the Compassion being extended outright upon the Line of Sines from 14 d.40 m.to 43 d. 20 m. and that extent applied the same way upon the Line of Numbers from 100, the moveable Point willfall upon 271, the parts of the fide D, B.

And here observe, that not only this present Problem, but also all those that follow (which concern the refolution of Triangles) may be refolved two manner of wayes, viz. by working either outright or across, except some few, which we intend to mark in their proper places. Remember likewife what hath been before touched in the fecond Chapter aforegoing, viz. that the Mean Line of Numbers ir the only Line to be used with these of Sines and

Tangents, and no other.

PR Ø B L. 2.

By the Knowledge of two Sides and an Angle opposed to one of them, to find the other row Angles and the third Side.

"His is the Inverse of the last Problem: for, as the fide opposed to the given Angle is, to the Sine of the same Angle: so is the other fide

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D, B. known, to the Sine of the Angle thereunto oppoe A- fed : And therefore

Extend the Compasses across from the parts of the side apposed to the Angle known, unto the Sine of the same Angle: then that extent being applied the same way z haz nbers from the parts of the other known fide, will cause the movable Point to fall upon the Sine of the Angle re-335. quired. paffics

So in the forefrid Triangle C, B, D, the fide C, B, being 335; the Angle D (opposed thereunto) 122 d. o m. and the fide D, C, 100, the Angle B will be found 14 d. 40 m. For if you extend the Compafics across from 335 upon the Line of Numbers, to 122 d. o m. (or rather to 18 d. o m. as aforesaid) upon the Pro-Line of Sines, and after apply that extent the sime way from 100 upon the Line of Numbers, the moveable Point will rest upon 14 d. 40 m. the measure of the Angle B required.

Now having the knowledge of two Angles, the other may be easily diffcovered, being the Complement of those two to 180, as aforefuld : And the Angles being known, the other fide may be also found by the Problem aforegoing.

PROBL. 3.

By the Knowledge of two Sides and the Angle included, to find the other two Angles and the third Side.

IF the Angle included be a right Angle, this is the Proportion : as the greater fide is to the leffer ; fo is the Tangent of 45 d. o m. to the Tangent of the leffer Angle. And therefore

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Extend the Compasses upon the Line of Numbers downwards from the greater to the less side: then if you apply that extent upon the Line of Tangents the same way from 45 d. the movable Print will fall upon the Tangent of

the leffer Angle.

Example; In the Restangle Triangle, A, B, D; of the Diagram aforegoing, the fide A, B; being 230, and the fide A. D, 143. 72; the Angle B will be found 32 d. o m. For, if you extend the Compasses downwards upon the Line of Numbers from 230 to 143. 72; that extent being applied the same way from 45 d. at the top of the Line of Tangents, will cause the movable Point to fall upon 32 d. o m. viz. the measure of the Angle B; whose Complement 58 d. o m. is the measure of the Angle D.: And now the three Angles being thus discovered, the third side may also be known by the first Problem of this Chapter.

Chapter.

But If the included Angle be Oblique, viz. either obtule or acute, then this is the Analogy. As the Sum of the fides known is, to the difference of the fime fides: so is the Tangent of the half. Sum of the Angles unknown, to the Tangent of half their

difference: And therefore

Extend the Compasses upon the Line of Numbers downwards and upright from the Sum of the given sides; unto their dissernce: then applying that extent upon the Line of Tangents from the half Sum of the Angles unknown; the movable. Point will fall upon the Tangent of half their difference; which being added unto the said half Sum; make up the greater, but being dedusted from it discovers the lesser of the Angles you look for.

An Example of this Problem, when the moity of

the Angles opposed exceeds not 45 d.

In the Triangle B; C; D; the fide D, B, being 271; the fide D; I; 100, and the Angle D; 122 d.the Angle E will be found 14 d. 40 m. and the Angle C; 43 d. 20 m. For, if you extend the Compaffes upon the

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Mean Line of Numbers downwards from 371 (the Sum of the fides known) to 171 (their difference) that extent being applied the same way upon the Line of Tangents from 29 d. (half the Sum of the Angles B and C, the movable Point will fall upon 14 d. 20 m. which being added to 29 d. amounts to 43 d. 20 m. for the Angle C; and being substracted out of them, the remainder is 14 d. 40 m. For the Angle B.

Two other Examples of this Problem, when the

moity of the Angles opposed exceeds 45'd.

1. In the same Triangle C; B; D; the side C; B; being 335, the side C; D; 100; and the Angle C; 43 d. 20 m. the Angle D will be 122 d. and the Angle B 14 d. 40 m. For; if you extend the Compasse upon the Line of Numbers downwards from 435 (the Sum of the sides known) to 235 (their difference) that extent being applied upon the Line of Targents backwards (viz. upwards) from 68 d. 20 m. (the half Sum of the Angles D and B required) the movable Point will fall upon 53 d. 40 m. which being added to 68 d. 20 m. their Sum is 122 d. 0 m. viz. the intesture of the Angle D; and being deducted out of the same 68 d. 20 m. the remainder is 14 d. 40 m. the Angle B.

2. The fide B; C, being 335, the fide B; D; 271; and the Angle B 14 d. 40 m. I demand the Angles D and C: the Sum of the fides B; C; and B; D; is 606, their difference is 64, and the Angle C being 14 d. 40 m. the Sum of the Angles opposed and unknown is 165 d. 20 m. and half that is 82 d. 40 m. Now to fatisfie this demand, I extend the Compaties upon the Line of Numbers downwards from 606 to 64: then, because if I apply that extent upon the Line of Tangents backwards (viz. upwards, as before) from 82 d. 40 m. the movable Point will fall as far beyond the top of that Line, at the Term I look for is fituate on this fide, I apply that extent, down-

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downwards from 45 d. o m. causing the movable for Point also to fall upon the same Line: that done able and the movable Point remaining there fixed, I close such the Compasses till the other Point may rest upon in \$2 d. 40 m. And having the Compasses so extended, if applying that extent downwards, I set one of the Points at 45 d. the other will reach to 39 d.20 m. which being added to 82 d. 40 m. amounts to 122 d. viz. the Angle D: but being deducted out of 82 d. 40 m. the remainder is 43 d. 20 m. viz. the measure of the Angle C.

And in these three Cases having discovered the three Angles, the other side may be likewise found by the first Problem of this Chapter: Observe also that these two last Examples will not admit of crosswork: and therefore are Exceptions to the General Rule delivered in the end of the same Problem.

PROBL. 4.

The three Sides being known to find the Perpendicular, and the three Angles.

The greatest side being assigned for the Base, upon which the Perpendicular shall be supposed
to sall, find the Sum and the difference of the
other sides: that done, the Proportion will be this;
As the Base is to the Sum of the other sides, so is the
difference of the other sides to a fourth Number
which being deducted out of the Base, the Perpendicular will sall in the middle of that which termain;
Andth erefore

Extend the Compasses upon the Line of Numbers from the parts of the Base unto the Sum of the parts of the other sede: thus done, and that extent applyed the same way

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e-alfo Example, in the Triangle E, F, G, the fide E, F, bcing 13, the fide F, G, 11, and the Bafe E, G, 20, I de-Croft neral mand the Point of the Base, where the Perpendicular ought to fall, and then the three Angles of the same Triangle: The Sum of the sides is 24, and their difference is 2: I extend therefore the Compaffes upon the Line of Numbers from 20 to 24: that done in this Example (because by the third Corollary of the fift Problem of the third Chapter, the Numbers 20 and 2 are both represented at the sime Point) you may observe (without any farther search) the movable Point to discover the parts of the Segment E. C. viz. 2. 4, which being deducted out of 20, there remains 17, 6, whose half is 8, 8, which are the parts of the Bafe comprehended berwixt C and A. or betwirt A and G: I conclude therefore that A is the Point of the Base where the Perpendicular ought to fall. Now in the Triangle A, F, G, the fides A, G, and G, F, being known, as also the Angle F, A, G, (which is a right Angle by the 10. Def. of the 1. El. of Eucl.) the Angles G, and F, as alfo the Perpendicular F, A. may be found by the I and 2 Probl. of this Chapter. In like manner in the Triangle E, F, A, the fides E.A. and E, F, as also the Angle E, A, F, being known. the Angles E, and F, may be found by the 2. Probl.

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of this Chapter. And lastly, if you add the Angle the E, F, A, and A, F, G, together, their aggregate will be make up the Angle E; F; G: And 6 by the known fix ledge of the three sides have you all the parts of that Po Triangle throughly resolved.

PROBL. V.

The three Sides being known, to find be the Area, or Superficial Content.

From the half Sum of the three fines deduct each fide, to the end you may discover the difference betwirt the aid half Sum and each fide: that done, the Proportions will be as followeth:

I. As I is to the first difference; so is the second difference to a fourth Number.

2. As I is to that fourth Number, so is the third difference to a sixth Number.

3. As I is to that fixth Number, so is the half Sum to an eighth Number, whose Square-Root is the Area re-

quired.

Example; The three fides of the forcaid Triangle E, F, G, being 20, 13, and 11, their Sum is 44, half thereof is 22, and the differences betwixt each fide and that half are 2, 9, and 11: The operation being thus prepared (because the Number required is a Square-Root) I extend the Compasses upon the Mean Line of Numbers upwards from 1 to 2.: then that extent being applied the same way from 9 (in the first part of that Line) the movable Point will fall upon 18 the fourth Number: this done, and the movable Point remaining there fixed, close the Compasses till the other Point fall again upon 13: for that extent being applied from 11, will cause

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Angle the movable Point to fall upon 198, the fixth Num
te wil ber: again, the movable Point remaining there
know fixed, as before, open the Compafies till the other
of that Point may yet again fall upon 1, and may intercept between the Legs the distance betwixt 1, and
198: for that done; if you apply the same extent
(in the first part of the same Line) from 22, the
movable Point will fall upon 4356, whose SquareRoot (by the 12. Probl. of the last Chapter) will appear at the same Point upon the Great Line of Numbers to be 66, which is also the Great required.

2. Of Spherical Rectangle Triangles.

PROBL. 6.

The two Sides being given, to find the Base.

IN Spherical Rectangle Triangles, the fide which fubtends the right Angle, is called the Base, which to find by the knowledge of the other fides, use this Analogy following:

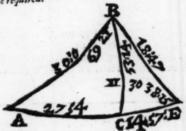
As the Radius or Sine of 90 d. is to the Sine of the Complement (otherwise called the Co-fine) of one of the sides: so is the Co-fine of the other side to the Co-fine of the Base: And therefore

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Extend the Compasses downwards uppon the Line Sines from 90 d. to the Co-Sine of one of the sides: the excapplying that extent the same way from the Co-Sine of the for other side, the movable Point will rest upon the Co-sine greek the Base required.



Example. In the Triangle A, B, C, the fide A, despecing 27 d. 54 m, and the fide C, B, 11 d, 30 m, the Si Base B, A, will be found 30 d. 0 m. for if you extend The Compasses downwards from 90 d. to 62 d. 6 m for (the Complement of 27 d. 54 m. and after apply what extent the same way from 78 d. 30 m. (the Complement of 11 d. 30 m.) the movable Point will Call upon 60 d. being the Complement of 30 d. the Base required.

PROBL. 7.

The two Sides being known, to find either of the Oblique Angles.

As the Sine of the fide next the Angle required is to the Radius: for is the Tangent of the opposite fide to the Tangent of the tame. Angle And therefore

1. When

Lines 1. When the fide opposed to the Angle required les: the exceeds not 45 d. Extend the Compasses upon the Line of the Sires from the Sine of the side adjacent to the Angle Co-sine crequired, to 90 d. then that extent being applied the same way upon the Line f Tangents, from the Tangent of the fide opposed to the required Angle, the movable Point will fall upon the Tangent of the Same required Angle.

1. Example, In the faid Triangle A,B,C, the fide A,C, being 27 d. 54 m. and the fide C,B, 11 d. 30 m. I demand the Angle A. Extend the Compasses uponthe Line of Sines from 27 d. 54 m. to 90 d. then that extent being applied the time way upon the Line of Tangents from 11 d. 30 m. the movable Point will

rest upon 23 d. 30 m. the Angle A required.

Or otherwise thus: Extend the Compasses across from 27 d. 54 m. upon the Line of Sines to 11 d.; 30 w. upon the Line of Tangents: then applying that e A. dextent the same way from 90 d. upon the Line of m. the Sines, the movable Point will fall upon the Line of extend Tangents at a Point representing 23 d. 30 m. as be-1. 6 m fore. And note, that in this cale the Term required apply will always fill out to be less then 45 d.

or (the 2. Example, To know the Angle R.: Extend the at will Compasses upon the Line of Sines from 11 d. 30 m. d. the to 90 d. then (because that extent being applied upon the Line of Tangents the fime way from 27 d. 54 m. will cause the movable Point to fall as far beyond the top of that Line, as the Term required is fituate on this fide) apply the same extent bickwards upon the Line of Tangents from 45 d. causing dei the movable Point to fall allo upon the sime Line: for, that done, and the movable Point remaining fixed at the Point where it falls, close the Compasses till the other Point may fall upon 27 d. 54 m, And at last that extent being applied outright upon the Line of Tangents from 45 degr. will cause the movengle, able Point to rest upon 69 d. 21 m. the Angle B. required. Or otherwife: Extend the Compaffes a-

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cross from 11 d. 30 m. upon the Line of Sines to 27 d. 54 m. upon the Line of Tangents: then if you apply that extent backwards from 90 d. upon the Line of Sines, the movable Point will fall upon the Line of Tangents at a Point representing 69 d. 21 m. as before. And here the required Angle is always The greater than 45 d.

2. When the fide opposed to the Angle required exceeds 45 d. Extend the Composses upon the Line of Sines from the Sine of the fide adjacent to the Angle required, to 90 d. That done, if you apply that extent backwards upon the Line of Tangents from the Tangent of the fide opposed to the faid required Angle, the movable A Point will fa'l upon the Tangent of the fame Angle.

Example, In the Diagram annexed, the fide A, C, being 61 d. 53 m. and B, C, 54 d. 28 m. the Angle A will be found 57 d. 47 For, the Compafles being extended upon the Line of Sines from 61 d. 53 m. to 90 d. and that extent applied backwards upon the Line of Tangents from 54 d. 28 m. the movable Point will fall upon 57 d. 47 m. the Angle A required. And here offerve 1: that in



Examples of this kind you cannot work across: 2. men The Angle here found is alwayes greater than le L 45 d.

PROBL. 8.

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PROBL. 8.

The Base and one of the Oblique Angles being given, to find the other Oblique Angle.

The Padius to the Co-fine of the Base; so is the Tangent of the Angle known to the Cotangent of the Angle required: And therefore

I. When the Angle given exceeds not 45 d. Exmed the Compasses upon the Line of Sines from 90 d. to be Co-sine of the Base: then if you apply that extent the ame way upon the Line of Tangents from the Tangent of the Angle given; the movable Point will fall upon the stangent of the required Angle.

Example, In the Diagram of the fixth Probl. the last A, B, being 30 d. and the Angle A 23 d. 30 m. Re Angle B will be found 69 d. 21 m. For, if the impassive be extended upon the Line of Sines from 6 d. to 60 d. (the Complement of the Base) and hat extent applied the same way upon the Line of langents from 23 d. 30 m. the movable Point will strupon 20 d. 39 m. whose Complement (found also at the same Point) is 69 d. 21. m. the Angle B resired. Or otherwise by cross-work, thus: Extend the Compassive from 90 d. upon the Line of Sines to 3 d. 30 m. upon the Line of Tangents: then that twent being applied the same way from 60 d. upon the Line of Sines, the movable Point will fall upon the Line of Tangents at the Point representing 20 d. m. as before. And here observe, that (in this

ife) the Angle you look for is alwayes less than

2. When

2. When the Angle given is greater than 45 d. Extend the Compasses upon the Line of Sines from 90 d. to the Co-sine of the Base: this done, if you apply that extent upon the Line of Tangents backwards from the Tangent of the Angle given, the mouable Point will fall T

upon the Co-tangent of the Angle required.

1. Example, In the Diagram of the fixth Probl. 8, A, being 30 d. and the Angle B 69 d. 21 m. the Angle A will be found 23 d. 30 m. For if the Compaftes be extended upon the Line of Sines from 90 d. to 60 d. and that extent applied backwards upon the Line of Tangents from 69 d. 21 m, the movable Point will fall upon 66 d. 30 m. the Complement of 23 d. 30 m. the Angle A required. And in this case you cannot use cross-work, and the last Term found upon the Rule is alwayes greater than 45 d. but the Complement of the same statement of the same stat

Term required less.

2. Example, In the Diagram produced in the last last Probl. B. A. being 74 d. 6 m. and the Angle B 66 d. the 30 m. the Angle A will be found 57 d. 47 m. For, if the you extend the Compasses upon the Line of Sines from 90 d. to 15 d. 54 m. and then (because that extent being applied backwards, as before, upon the tou Line of Tangents from 66 d. 30 m. will cause the movable Point to fall beyond that Line) if you proceed as you were directed in the second Example of 2 the said last Probl. at last the movable Point will rest upon 32 d. 13 m. the Complement of the Angle of the Compasses from 90 d. upon the Line of Sines to the 66 d. 30 m. upon the Line of Tangents: This done, the figure of the Line of Sines, the movable Point will rest upon the Line of Sines, the movable Point will rest upon the Line of Tangents at the Point representing 17 and 13 m. as before. And (in this case) the last at Term sound upon the Rule is always less than 45 d but but the Term required greater.

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PROBL

I fall The Base and one of the Oblique Angles being known, to find the Side adjacent to the same Angle.

wable A S the Radius is to the Co-fine of the Angle ent of known; so is the Tangent of the Pase to the Tangent of the fide required : And therefore, found 1. When the Base is less than 45 d. Extend the

at the Compasses upon the Line of Sines from 90 d. to the Coine if the Angle known: then applying that extent the ie last same way upon the Line of Tangents from the Tangent of 66 d the Base, the movable Point will fall upon the Tangent of

or, if the fide required.

Sines So in the Diagram of the fixt Problem, B, A, be-

Sines So in the Diagram of the fixt Problem, B, A, beat exing 30 d. and A 23 d. 30 m. the fide A, C, (whether on the four work outright or across) will be found 27 d. 54. See the m. And in this case the Term required is alwayes a pro-effer than 45 d.

2. When the Base exceeds 45 d. Extend the complete of 2. When the Base exceeds 45 d. Extend the complete Angle known, as before: that dene, if you apply the stend sime extent upon the Line of Tangents backwards from the Tangent of the Base, the movable Point will rest upon done, be Tangent of the side required.

54 m. So in the Diagram produced in the seventh Pro-ll rest blem, B, A, being 74 d.6 m. and the Angle A 57 d. enting 7 m. the side A.C. will be found 61 d. 53 m. And e last n this case you cannot work across, and the side to be 45 d bund will be always greater than 45 d.

Now if in applying the extent of the Compasses

Now if in applying the extent of the Compasses from the Tangent of the Base, the movable Point falls

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falls beyond the Line, work as you were before directed in the second Example of the seventh Problem aforegoing, and so shall you also in that case discover the side you look for, which will then always happen to be less than 45 d.

P R. O B L. 10.

The Base and one of the Oblique Angles being known, to find the Side opposed to the same Angle.

A S the Radius is to the Sine of the Bafe, so is the Sine of the Angle known to the Sine of the Side required: And therefore

Extend the Compasses upon the Line of Sines from 90 d to the Sine of the Base: Fir, that extent being applyed the same way from the Sine of the given Angle will cause the movable Point to fall upon the Sine of the side required.

Example, In the Diagram of the fixth Problem; to know the fide B, C, extend the Compaffes upon the Line of Sines from 90 d. to 30 d. then if you apply that extent the same way from 23 d. 30 m. the movable Point will fall upon 11 d. 30 m. the side required.

PROBL. II.

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PROBL. 11.

One of the Sides and the Oblique Angle next unto it being known, to find the Base.

A S the Co-fine of the Angle known is to the Radius; so is the Tangent of the fide given to the Tangent of the Base: And therefore,

1. When the fide given exceeds not 45 d. Extend the Compasses upon the Line of Sines from the Co-sine of the Angle given, unto 90 d. The done, and that extent applied the same way upon the Line of Tangents from the Tangent of the side given, will cause the movable Point to fall upon the Tangent of the Base. So in the Diagram of the sixth Probl. the Angle A being 23 d. 30 m. and the side A, C, 27 d. 54 m. the Base B, A, will be found 30 d. 0 m. But here, if the moveable Point chance to fall beyond the Line, proceed as you have been before directed in the second Example of the 7. Probl. And in that case the Term required will alwayes prove greater than 45 d.

2. When the given fide exceeds 45 d. Extend the Compasses upon the Line of Sines from the Co-sine of the Angle given, unto 90 d. then, if you apply that extent upon the Line of Tangents backwards from the Tangent of the side given, the movable Point will fall upon the Tangent of the Base. So in the Diagram of the seventh Probl. the Angle A being 57 d. 47 m. and the side A, C, 60 d. 53 m. the Base B, A, will be found 74 d. 6 m. And here the Term sought for is always great-

or than 45 d.

D PROB.

PROBL. 12.

One of the Sides and the Oblique Angle next unto it, being known, to find the other Side.

A S the Radius is to the Sine of the fide given; fo is the Tangent of the Angle known to the Tangent of the fide required: And therefore

1. When the Angle given exceeds not 45 d. Extend the Compasses upon the Line of Sines from 90 d. unto the Sine of the given side: thu done, and that extent applied the same way upon the Line of Tangents from the Tangent of the Angle known; will cause the movable Point to fall upon the Tangent of the side required; So in the Diagram of the sixth Probl. A, C; being 27 al. 54 m. and the Angle A, 23 d. 20 m. the side B; C. will be found 11 d. 30 m. And in Examples of this kind cross-work may be used, and the Term sought

for is always less than 45 d.

2. When the Angle given exceeds 45 d. Extend the Compasses as before: which done, if you apply that extent upon the Line of Tangents backwards from the Tangent of the given Angle, the movable Point will fall upon the Tangent of the siderequired. So in the Diagram of the seventh Probl. B; C, being \$4 d. 28 m. and the Angle B, 66 d. 30 m. the side A, C will be found 61 id. \$3 m. This Example and the like cannot be performed by cross-work; and here the Term found is always greater than 45 d. But if in applying the Compasses backwards the movable Point chance to fall beyond the Line, work as you were before directed in the second Example of the seventh Problem

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blem of this Chapter, and then will the Term required be alwayes less than 45 d.

PROBL. 13.

One of the Sides and the Oblique Angle next unto it being known, to find the other Oblique Angle.

A S the Radius to the Co-fine of the given Side; fo is the Sine of the Angle known, to the Co-fine of the Angle required: And therefore

Extend the Compasses upon the Line of Sines from 90 d. to the Co-sine of the side given: this done, that extent being applied the same way from the Sine of the given Angle; will reach to the Co-sine of the Angle required. So in the Diagram of the sixth Problem A; C, being 27 d. 54 m. and the Angle A 23 d. 30 m. the Angle B will be found 69 d, 21 m.

PROBL. 14.

One of the Sides and the Angle opposed unto it being known, to find the Base.

A S the Sine of the Angle given is to the Sine of the fide given: so is the Radius to the Sine of the Base: And therefore

Extend the Compasses from the Sine of the Angle give

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to the Sive of the given side: then if you apply that extent from 90 d. the movalle Point will fall upon the Sine of the Base. So in the Diagram of the fixth Problem, A, being 23 d. 30 m. and the side B, C, II d. 30 m. the Base B, A, will be found 30 d. 0 m.

PROBL. 15.

One of the Sides and the Angle oppofed unto it being known, to find the other Oblique Angle,

A S the Co-fine of the fide given is to the Co-fine of the Angle given; to is the Kadius to the Sine of the Angle required: And therefore,

Extend the Compasses from the Co-sine of the given side, to the Co-sine of the given Angle: this done, that extent being applied the same way from the Radius, will cause the movable Point to fall upon the Sine of the Angle required. So in the Diagram of the fixth Problem, the side A, C, being 27 d. 54 m. and the Angle B, 69 d. 21 m. the Angle A, will be found 23 d. 30 m.

PROBL. 16.

One of the Sides and the Angle oppofed unto it being known, to find the other Side.

As the Tangent of the Angle given is to the Tangent of the fide given; to is the Radius to the

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the Sine of the fide required: And therefore,

1. When neither the Angle nor fide given exceeds 45 d. Extend the Compasses devinerals upon the Line of Tangents from the Tangent of the Angle given, to the Tangent of the fide given: this done, the extent leing applied the same way upon the Line of Sines from 90 d. with reach to the Sine of the fide required.

So in the Diagram of the fixth Problem, the Angle A being 23 d. 30 m and the fide B, C, 11 d. 30

m. the fide A, C, will be found 27 d.54 m.

2. When the Angle and the fide given do each of them exceed 45 d. Extend the Compasses upon the Line of Tangents upwards from the Tangent of the Angle given to the Tangent of the side given, then if you apply that extent backwards upon the Line of Sines from 90 d. the movable Point will fall upon the Sine of the side required.

So in the Diagram of the Eventh Problem, the Angle B being 66 d. 30 m. and the fide A, C, 61 d. 53 m. the fide B, C, will be found 54 d. 28 m.

3. When the Angle is greater, and the fide less then 45 d. Extend the Compasses upon the Line of Tangents devonwards from 45 d. to the Tangent of the Angle given, then if that extent be applied the same way from the Tangent of the given side, the moval le Point with fall upon a Point, which upon the Line of Sines represents the Sine of the side required.

So in the Diagram of the fixth Problem, the Angle B being 69 d. 21 m. and the fide A, C, 27 d. 54 m. the fide B, C, will be found 11 d. 30 m. And here observe, that Examples of this kind may likewife be performed by crofs-work, the extent of the Compaffes being applied backwards: For, having extended the Compaffes across from 69 d. 21 m. upon the Line of Tangents to 90 d. upon the Line of Sines, if you apply that extent backwards and across from 27 d. 54 m. upon the Line of Tangents, the movable Point will fall upon the Sine of 11 d. 30 m. the fide required.

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PROBL. 17.

One of the Sides and the Base being known, to find the Angle opposed to the same Side.

A S the Sine of the Base is to the Radius; so is the Sine of the fide known to the Sine of the Angle required: And therefore,

If you extend the Compasses from the Sine of the Base unto 90 d. that extent being applied the same way, will reach from the Sine of the great side unto the Sine of the Angle required. So in the Diagram of the fixth Problem, B, A, being 30 d. and the side B, C; II d. 30 m. the Angle A will be found 23 d. 30 m.

PROBL. 18.

One of the Sides and the Base being known, to find the Oblique Angle adjacent unto that Side.

A S the Tangent of the Base is to the Tangent of the given side; so is the Radius to the Co-sine of the Angle required: And therefore,

1. When neither the Base nor the side given exceeds 45 d. the extent from the Tangent of the Base to the Tangent of the side given, being applied the same way, will reach from 90 d. to the Cosine of the Anglere-coursed.

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So in the Diagram of the fixth Problem, the Bate B, A, being 30 d. and the fide A, C, 27 d. 54 m. the Angle A will be found 23 d. 30 m. And in this cate cross-work may also be used, if you apply the Compasses the same way they were extended.

2. When the Base and the side given do each of them exceed 45 d. The extent upwards from the Tangent of the Base to the Tangent of the given side being applied backwards, will reach from 90 d. to the Co-sine of

the Angle required.

So in the Diagram of the seventh Problem, the Base B, A, being 74 d. 6 m. and the side A, C, 61 d. 53 m. the Angle A will be found 57 d. 47 m. Howbeir in this case cross-work hath no place.

3. When the Base is greater, and the side I so than 45 d. Work as you were taught in the third Role of the

fixt centh Problem aforegoing.

PROBL. 19.

One of the Sides and the Base being known, to find the other Side.

A S the Co-fine of the fide given is to the Radius; to is the Co-fine of the Bafe to the Co-fine of the fide required: And therefore,

The extent from the Co-fine of the side given to 90 d. being applied the same way, will reach from the Co-sine of

the Bafe, to the Co-fine of the fide required.

So in the Diagram of the fixth Problem the Bate B, A, being 30 d. and the fide A, C, 27 d. 54 m. the fide B, C, will be found 11 d. 30 m.

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PROBL. 20:

The two Oblique Angles being known, to find the Base.

A S the Tangent of one of the Angles is to the Cotangent of the other Angle; so is the Radias to the Co-sine of the Base: And therefore.

- 1. When one of the Angles given, and the Complement of the other are each of them less than 45 d. The extent from the Tingent of the Angle less than 45 d. anto the Co-tangent of the other, will reach from 50 d. to the Co-fine of the Buse. So in the Diagram of the fixth Problem the Angle A being 23 d. 30 m. and the Angle B 69 d. 21 m. the Base B, A, will be found 30 d. And here cross-work may likewise be used.
- 2. When one of the Angles is greater, and the Complement of the other less than 45 d. Proceed as you have been taught in the thard Rule of the 16. Frether Aregoing.

PROBL. 21.

The two Oblique Angles being known, to find either of the Sides.

A S the Sine of one of the Angles is to the Cofine of the other Angle: to is the Radius to the Coline of the fide opposite to the Angle, whose Co-fine was taken: And therefore,

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The extent from the Sine of one of the Angles given, to the Co-fine of the other, being applied the same way, will reach from 90 d. to the Co-fine of the side apposed to the Angle, whose Co-fine was taken.

So in the Diagram of the fixth Problem, the Angle A being 23 d. 30 m. and the Angle B 69 d. 21 m

the fide A, C, will be found 27 d. 54 m.

3. Of Spherical Oblique Angle Triangles.

PROBL. 22.

Two Angles and a Side opposed to one of them being known, to find the Side opposed to the other.

A S the Sine of the Angle subtended by the side known is to the Sine of the same side; so is the Sine of the Sine of the side side required, to the Sine of that side: And therefore,

The extent from the Sine of the Angle opposed to the side known, unto the Sine of the same side, being applied the same way from the Sine of the Angle opposed to the side required, will reach to the Sine of the side so required.

So in the Diagram of the fixth Problem, the Angle E, being 38 d. 15 m. the fide B, A, 30 d. and the Angle A 23 d. 30 m. the fide B, E, will be found 18 d. 47 m.

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PROBL. 23.

Two Sides and the Angle apposed to one of them being known, to find the Angle opposed to the other Stae.

A S the Sine of the fide fubtending the Angle known is to the Sine of the fame Angle; to is the Sine of the fide fubrending the Angle required, to the Sine of that Angle: And therefore,

The extent from the Sine of the side subtending the Angle known , to the Sine of the same Angle, being applied the same way, will reach from the Sine of the side subtending the Angle required, to the Sine of that Angle.

So in the Diagram of the fixth Problem, B, A, being 30 d. the Angle E 38 d. 15 m. and the fide B. E, 18 d. 47 m. the Angle A will be found 23 d. 30 m.

The fludious Reader hath by this time (I prefume) fo well acquainted himself with the turnings and windings of this Instrument, that in the refelution of most of the answing Problems, it will (I concerve) be only necessary to produce the bare Analogy, without annexing either Rule or Example as heretofore, and to refer the proper applisation thereof, to his farther industry and discretion.

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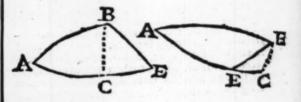
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PROBL. 24.

In any of the Triangles annexed, the Sides A, B, and A, E, together with the Angle A, being known, to find the Side B, E,



I Nan ObliqueAngle Triangle, when the Terms propounded are two fides and one Angle, or two Angles and one fide, and yet the Term required undificoverable by the two laft premifed Problems, you are to con-



vert such a Triangle into two Rectangle Triangles, by supposing a Perpendicular to be let fall from any one of the Angles upon his opposite side, in such fort that two of the Terms propounded may in one of those Rectangle Triangles still remain given and intire; for by this means all the other parts of such a Triangle thus converted, may be readily discovered by the Analogies of Rectangle Triangles: And the Perpendicular thus imagined, will fall within the Triangle, when the Angles adjacent to the side upon.

upon which it falls, are of one and the same kind that is, both acute, or both obtuse; but otherwise without the Triangle, when those Angles are of differing kinds, viz. the one acute and the other obtuse, as plainly appears by the Triangles annexed, in which (naving the sides A, B, and A, E. as also the Angle A propounded) to find the side B, E, use these Analysies following:

1. As the Radius is to the Co-fine of A; to is the

Tangent of A, B, to the Tangent of AC,

2. As the Co-fine of \mathcal{A} , \mathcal{C} , to the Co-fine of \mathcal{C} , \mathcal{E} ; so the Co-fine of \mathcal{A} , \mathcal{B} , to the Co-fine of \mathcal{B} , \mathcal{E} .

And here observe, that to come to the knowledge of C, E, in cases that resemble the first of the Diagrams annexed, having found A, C, you are to deduct it out of A, E; again, in such cases as are like the second Diagram, A; E, ought to be deducted out of A, C; and lastly in those that resemble the third Diagram, A, C, and A, E, are to be added together.

PROBL. 25.

In the same Triangles, A,B, and A, E, together with the Angle A, being known, to find either of the other Angles, and namely (for Example) the Angle E.

2. As the Radius to the Co-fine of A; to is the Tangent of A, B, to the Tangent of A, C.

2. As the Sine of C, E, to the Sine of A, C; to is the Tangent of E, to the Tangent of E.

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PR OBL. 26.

A, B, and B, E, together with A, being known, to find A, E.

The Radius to the Co-fine of \mathcal{A} ; so is the Tangent of \mathcal{A} , \mathcal{B} , to the Tangent of \mathcal{A} , \mathcal{C} .

2. As the Co-fine of \mathcal{A} , \mathcal{B} , to the Co-fine of \mathcal{B} , \mathcal{E} ; so is the Co-fine of \mathcal{A} , \mathcal{C} , to the Co-fine of \mathcal{C} , \mathcal{E} .

PROBL. 27.

A, B, and B, E, together with A, being known, to find B.

1. A 5 the Radius to the Co-fine of A, B; so is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Tangent of B, E, to the Tangent of A, B; so is the Co-line of A, B, C, to the Co-line of C, B, E.

PROBL. 28.

A, and B, together with A, B, being known, to find either of the other Sides, and namely (for Example) the Side B, E.

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1. A S the Radius to the Co-fine of A, B; so is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Co-fine of C, B, E; to the Co-fine of A, B, C; so is the Tangent of A, B, to the Tangent of B, E.

PROBL. 29.

A, and B, together with A, B, being known, to find E.

A S the Radius to the Co-fine of A, B; so is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Sine of A, B, C, to the Sine of C, B, E; to is the Co-fine of A, to the Co-fine of E.

PROBL. 30.

A, and E, together with A, B, being known, to find A, E.

A S the Radius to the Co-fine of A; so is the Tangent of A, B, to the Tangent of A, C.

2. As the Tangent of E, to the Tangent of A; so is the Sine of A, C, to the Sine of C, E.

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PROBL. 31.

A, and E, together with A, B, being known, to find B.

1. A S the Radius to the Co-fine of A, B: (6 is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Co-fine of \mathcal{A} , to the Co-fine of E: to is the Sine of \mathcal{A} , \mathcal{B} , \mathcal{C} , to the Sine of \mathcal{C} , \mathcal{B} , \mathcal{E} .

PROBL. 32.

Three Sides being known, to find any of the Angles.

A Dd the three fides together, then from the half Sum thereof fubftract the fide opposite to the Angle required: this done, the Proportions will be as followeth:

1. As the Radius to the Sine of one of the sides including the Angle required: so in the Sine of the other side including the same Angle to a fourth Sine.

2. As that fourth Sine is to the Sine of the half Sum of the fide: so is the Sine of the difference betwist that half Sum, and the side opposed to the Angle required, to a seventh Sine, betwist which and 90 d. (at the end of the Line of Sines) if you with your Compasses discover the half distance, that Point shall represent unto you an Ark, whose Complement being doubled is the Angle you look for.

So in the Diagram of the 6. Problem the fide A, B, being

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B, being 30 d. the fide B, E, 18 d. 47 m. and the fide A, E, 42 d. 51 m. I demand the Angle B: The Sum of the Sides is 91 d. 38 m. half that Sum is 45 d. 49 m. The fide A. E, being substracted out of that half, there remains 2 d. 58 m. And therefore to discover the Angle B, proceed thus:

Bxtend the Compasses upon the Line of Sines from 90 d. unto 30 d. then applying that extent the same way, and upon the same Line from 18 d. 47 m. the movable Point will fall upon 9 d. 16 m. Again, that Point remaining there fixed, extend the Compasses so far that their other Point may rest upon 45 d. 49 m. this done, and that extent applied the simeway from 2 d. 58 m. will cause the movable Point at less to fall upon 13 d. 20 m. whose half distance towards 90 d. will happen upon a Point representing 28 d. 42 m. whose Complement (viz. 60 d. 18 m.) being doubled, amounts to 122 d. 36 m. the quantity of the Angle B required.

PROBL. 33.

The three Angles being known, to find any of the Sides.

IF in stead of the greatest Angle, you take his Complement to 180 d. the Angles convert themselves into sides, and the sides into Angles, and then (by consequent) the operation will be the same with that of the last Problem.

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4. Of divers other Geometrical Figures.

PRobl. 34. The Diameter of a Circle being known, to find the Circumference.

The extent upon the Line of Numbers from 1 to the Diameter, will reach from 3.142 to the Circumference.

Probl. 35. To find the Superficial Contat.

The extent from I to the Diameter being twice repeated from .7854, will reach to the Content O, otherwife thus: The extent upon the Great Line of Numbers, from I to the Diameter, will reach upon the Mean Line of Numbers from .7854 to the Content: Or yet thus; the Extent upon the Great Line of Numbers from I to .7854 will reach upon the Mean Line of Numbers from the Diameter to the Content. And in this manner may divers of the infuing Problems be divertified, which (as before) I refer to the differetion of the Practioner.

Probl. 36. To find the side of the Square, which may

be inscribed within the same Circle.

The extent from 1 to .7071 will reach from the Diameter to the fide of the Square required.

Probl. 37. Having the Circumference to find the D.-

The extent from 1 to 3183 will reach from the Circumference to the Diameter.

Probl. 38. To find the Superficial Content.

The extent from 1 to the Circumference being twice repeated from .07958, will reach to the Content. Or. 66.

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Probl. 39. To find the fide of the Square, which may be inscribed within it.

The extent from 1 to the Circumference, will reach from 2251 to the fide of the Square required.

Probl. 40. Having the Content of a Circle, to find the

Diameter.

The extent from 1 to 1, 273 will reach from the Content to another number, whose Square Root is the Diameter required.

Probl. 41. To find the Circumference.

The extent from 1 to 12.57 will reach from the Content to another Number, whose Square Root is the Circumference required.

Probl. 42. To find the side of the Square equal un-

to it.

Bxtra the Square Root thereof by the 12. Probl. of the last Chapter, and you have your defire.

Probl. 43. The breadth of a long Square being given in Inch-measure, and the length in Foot-measure, to find

the Content in Feet.

The extent from 12 to the breadth in Inches, will reach from the length in Feet to the Content in Feet. Or, vice versa, the extent from 12 to the length in Feet, will reach from the breadth in Inches to the Content in Feet.

Probl. 44. The breadth and length of a long Square being given in Foot-measure to find the Content thereof

in Tards.

The extent from 9 to the breadth, will reach from the length to the Content in Yards. Or, &c.

Probl. 45. To find the Content in fingle Perches.

The extent from 16. 5 to the breadth, will reach from the length to the Content in fingle Perches Or, &c.

Probl. 46. To find the Content in Square Perches ; o-

therwife (in Architecture) called Poles.

The extent from 272. 25 to the breadth, will reach from the length to the Content in Poles. Or, &c.

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Probl. 47. The breadth and length of a long Square being given in Perches, to find the Content in Acres.

The extent from 160 to the breadth, will reach from the length to the Content in Acres. Or, &c.

Probl. 48. The breadth and depth of a Square Restangle folid, being given in Inch-measure, and the length in Fost-measure to find the Content thereof in Feet.

The extent from 12 to the breadth or depth in Inches, being twice repeated from the length in Feet, will reach to the Content in Feet. Or, &c.

Probl. 49. The breadth and depth of a Rectangle folid (not just square) being known) in Incl.-measure, and the length in Fost-measure to find the Content in Feet.

Find (by the tenth Problems of the last Chapter) the Mean Proportional betwixt the breadth and the depth; for then, the extent from 12 to that Mean Proportional, being twice repeated from the length in Feet, will reach to the Content in Feet.

Probl. 50. The breadth and depth of a Restangle folid (not just square) being known in Foot-measure, to find the Base or Superficies at the end thereof.

The extent from 1 to the breadth, will reach from

the depth to the Bafe required.

Probl. 51. The Base and length of a Rectangle solid being known in Foot-measure, to find the Content in Feet.

The extent from I to the Base, will reach from the length to the Content.

Probl. 52. Having the Diameter of a Cylinder, to

find the Bafe.

The Bate of a Cylinder being a perfect Circle this *Problem* may be refolved by the 35 aforegoing.

Probl. 53. The Base and length of A Cylinder being

known, to find the Content.

The extent from I to the Base, will reach from the length to the Content.

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Probl. 54. Having the Axis of a Sphere, to find the Superficial Content.

The extent from I to the Axis, being twice repeated from 3.142, will reach to the Superficial Cortent required. Or, &c.

Probl. 55. To find the folid Centent.

The extent from 1 to the Axs, being thrice repeared from .5238, will reach to the folid Content required. Or, oc.

CAP. VI.

The Use of the Rule of Proportion in Altronomy.

PROBL.

By the Sun's Shadow, to find his beight.

The extent upon the Mean Line of Numbers, from the length of the Rules Shadow to the height thereof (neld Perpendicular to the Hosizon) will reach upon the Line of Tangents from 45 d. to the Sun's height required.

Probl. 2. The Sun's greatest Declination, together with his distance from the next Equinoctial Point being

known, to find his present Declination.

As the Radius to the Sine of the Sun's diffance from the next Equinoctial Point; to is the Sine of

the

the Sun's greatest Declination to the Sine of the De-

Probl. 3. To find the Right Ascention.

As the Radius to the Tangent of his diffance. cc. so is the Co-fine of his greatest Declination to the Tangent of his Right Ascension.

Probl. 4. The Sun's greatest Declination, together with his present Declination, being known, to find his

Right Ascension.

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of he As the Tangent of his greatest Declination to the Radius, so is the Tangent of his present Declination to the Sine of his Right Ascention.

Probl. 5. The Elevation of the Pole, together with the Sun's Declination being known, to find how long the Sun

riseth or setteth before or after the hour of six.

As the Co-tangent of the Elevation is to the Radius; so is the Tangent of the Sun's Declination to the Sine of the Afentional Difference between the hour of fix, and the Sun's rising or setting.

Probl. 6. To find the Sun's Amplitude.

As the Co-fine of the Elevation is to the Sine of the Declination; so is the Radius to the Sine of the Amplitude.

Probl. 7. The Elevation of the Pole, the Sun's greatest Declination, and his distance from the next Equinostial

Point being known to find the Amplitude.

As the Co-fine of the Elevation is to the Sine of the Sun's diffance; so is the Sine of the Sun's greatest Declination to the Amplitude required.

Probl. 8. When the Sun is in the Equinoctial, by knowing the Elevation of the Pole, to find the Sun's height at a-

ny time assigned.

As the Radius to the Co-fine of the Elevation; fo is the Sine of the Sun's distance from fix a Clock

to the Sine of the height required.

Probl. 9. The Elevation of the Pole, and the Declination of the Sine being known, to find the Sun's height at the hour of six.

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As the Radius to the Sine of the Latitude; fo is the Sine of the Declination to the Sine of the height Su required.

Probl. 10. To find the Sun's height at any time af-

Ganed.

I. As the Radius to the Co-tangent of the Elevation, so is the Sine of the Sun's distance from fix, to the Tangent of an Ark, which being fubtracted out of the Sun's distance from the Fole, I fay again.

2. As the Co-fine of the Ark found is to the ·Co-fine of the refidue of the Sun's diftance from the Pole: io is the Sine of the Elevation to the Sine of

the height required.

Probl. 11. To find the time when the Sun will be

due East and West.

As the Tangent of the Elevation to the Radius so is the Tangent of the Declination to the Co-fine of the hour from the Meridian.

Probl. 12. To find the Sun's height, when he cometh

to be due East and West.

As the Sine of the Elevation to the Radius; fo is the Sine of the Declination to the height required. Probl. 13. To find the Sun's Azimuth at the hour

of fix. As the Co-fine of the Elevation is to the Cotangent of the Declination; to is the Radius to the

Tangent of the Azimuth from the North part of the Meridian.

Probl. 14. The Complement of Elevation, the Sun's distance from the Pole, and the Complement of the Sun's

Leight being known, to find the Azimuth.

Having added the three given Terms together, find the difference betwixt their half Sum and the Sun's distance from the Pole: this done, the Proportion will be as followeth:

1. As the Radius to the Co-fine of the Elevation fo is the Co-fine of the height to a fourth Sine:

2, As

fo is 2. As that fourth Sine is to the Sine of the half Sum; fo is the Sine of the difference to a seventh Sine, whole half diffance towards 90 d. will difcoafver the Sine of an Ark, whose Complement being doubled is the Azimuth you look for.

Probl. 15. To find the hour of the Day.

Having added the three given Terms together, as before, find the difference betwixt their half Sum and the Complement of the Sun's height; this done, the Proportions will be thefe:

1. As the Radius to the Co-fine of the Elevation 4 so is the Sine of the Sun's distance from the Pole to

a fourth Sine.

2. As that fourth Sine is to the Sine of the half Sum: so is the Sine of the difference to a seventh Sine, whose half distance towards 90 d. will discover the Sine of an Ark, whose Complement being doubled and converted into Time, will produce the hour required.

CAP. VII.

The Use of the Rule of Proportion in Dialling.

PROBL. 1. To make a direct Polar Dial.

Aving affigned a Line drawn in the middle of the Plane for the Meridian, and another Line

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Line drawn parallel unto it for fome other hour, which may be deferibed upon the Plane: I fay,

1. As the Tangent of that hour is to the Radius; fo is the distance of that Hour-line from the Meri-

dian to the height of the Stile.

2. As the Radius is to the height of the Stile; so is the Tangent of any other hour, to the distance of the same hour from the Substile.

Probl. 2. A Meridian Dial.

Having drawn a Line representing part of the Axn of the World towards a proper side of the Plane, (according to his situation either Eastward or Westward) assigned that Line for the hour of six, the Proportion will fall out to be as in the former Problem; for,

1. As the Tangent of any hours distance from fix is to the Radius; so is the distance of the hour upon the Plane from the Hour-line of fix, to the

height of the Stile.

2. As the Radius is to the height of the Stile; so is the Tangent of any other hours distance from fix to the distance of the same hour from the Sub-stile.

Probl. 3. An Horizontal Dial.

As the Radius to the Tangent of the hour given; to is the Sine of the Elevation to the Tangent of the Hour-line from the Meridian.

Probl. 4. A Vertical Dial.

As the Radius to the Tangent of the hour: so is the Co-fine of the Elevation of the Tangent of the Hour-line from the Meridian.

Probl. 5. A Vertical Inclining Dial.

Having found out the Elevation of the Pole above the Plane, according to its inclination, the Proportion will be this:

As the Radius to the Tangent of the Hour: so is the Sine of the Elevation above the Plane, to the Tangent of the Hour-line from the Meridian.

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hich Probl. 6. A Vertical Declining Dial.

1. As the Radius to the Co-tangent of the Elevation : fo is the Sine of the Declination to the Tangent of the Substile distance from the Meridian of the Place.

2. As the Radius to the Co-fine of the Declination: So is the Co-fine of the Elevation to the Sine of

the Stile's height above the Substile.

3. As the Sine of the Elevation is to the Radius : fo is the Tangent of the Declination to the Tangent of the Inclination of the Meridian of the Plane to or the Meridian of the Place.

4. As the Radius to the Sine of the Stile's height above the Substile: so is the Tangent of the Angle at the Pole comprehended between the hour given and the Meridian of the Plane, to the Tangent of

the Hour-lines distance from the Substile.

Probl. 7. A Meridian Inclining Dial. I. As the Radius to the Tangent of the Elevation: fo is the Sine of the Inclination to the Tangent of the Substile's distance from the Meridian.

2. As the Radius is to the Sine of the Elevation : fo is the Co-fine of the Inclination to the Sine of the

Stile's height above the Substile.

3. As the Co-fine of the Elevation is to the Radius : fo is the Tangent of the Inclination, to the Tan-

gent of the Inclination of Meridians.

4. As the Radius is to the Sine of the Stile's height above the Substile: so is the Tangent of the Angle at the Pole, to the Tangent of the Hour-lines distance from the Substile.

Probl. 8. A Polar Declining Dial.

1. As the Radius to the Sine of the Declination : to is the Co-fine of the Elevation to the Co-fine of the Ark comprehended between the Horizon and the Substile.

2. As the Radius to the Tangent of the Declinetion : fo is the Sine of the Elevation to the Tan-

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gent of the Inclination of Meridians, which being converted into time, sheweth how many hours the Substile ought to be placed from the Hour-line of II.

3. As the Radius is to the Tangent of the hours distance from the Substile : so are the parts of the height of the Stile, to the distance of the Substile from the Hour-line required, meafured by a Scale of like parts.

Probl. 9. A Declining Inclining Dial.

1. As the Radius to the Tangent of Inclination to the Horizon : fo is the Co-fine of Declination to the Tangent of the Ark of the Meridian of the Place intercepted between the Horizon and the Plane, which being compared with the Elevation of the Pole, the diffance of the Pole from the Plane may be thereby readily discovered.

2. As the Radius is to the Sine of Declination from the Vertical: so is the Sine of Inclination to the Horizon, to the Co-fine of the Inclination to the

Meridian.

3. As the Radius is to the Co-fine of Inclination to the Horizon: so is the Cotangent of Declination to the Tangent of the Ark of the Plane intercepted between the Horizon and the Meridian of the Place.

4. As the Radius is to the Sine of the Inclination to the Meridian : fo is the Tangent of the Pole's distance from the Plane, to the Tangent of the Sub-

stile's distance from the Meridian.

5. As the Radius is to the Pole's distance from the Plane: fo is the Sine of the Inclination to the Meridian, to the Sine of the Stile's height above the Substile.

6. As the Cofine of the Pole's diffance from the Plane is to the Radius: so is the Cotangent of the Inclination to the Meridian, to the Tangent of the Inclination of Meridians.

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7. As the Radius is to the Stiles height above the Subfile; to is the Tangent of the Angle at the Pole, to the Tangent of the Hour-line's diftance from the Subfile.

CAP. VIII.

The Use of the Rule of Proportion in Geography.

Probl. 1. Two Places being propounded, which differ only in Latitude, to find their Distance.

I. When the two places are fituate under the same Meridian, and upon the same side of the Equinoctial; Substract the lesser Latitude out of the greater; that done, the vermainder n the distance required.

2. When one of the places propounded is fituate upon this fide the Equinoctial, and the other upon that, and yet both under the fime Meridian, as before: Add the two Latitudes together; this done, their Sum is the distance required.

Probl. 2. Two places, which differ only in Longitude,

being propounded, to know their distance.

1. When the Places are both of them fituate under the Equinoctial: Subtract the leffer Longitude cut of the greater: this done, the remainder is the diffance required.

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2. When the Places are fituate under some Parallel betwixt the Equinoctial and one of the Poles: Then, as the Radius is to the Cofine of the common Latitude given: so is the Sine of half the difference of Longitude so the Sine of half the distance.

Probl. 3. Two places being given, which differ both

in Longitude and Latitude, to find their distance.

1. When one of the Places is fituate under the Equinoctial, and the other towards one of the Poles: Then, As the Radius is to the Co-fine of the difference of Longitude: so is the Co-fine of the Latitude given,

to the Cofine of the distance required.

2. When both Places are without the Equinoctial, and towards one of the Poles: Then, As the Radius is to the Co-fine of the difference of Longitude: fo is the Co-tangent of the leffer Latitude to the Tangent of ancther Ark, which being substracted out of the Complement of the lesser Latitude, retain the Ark thereof remaining; and fay again, As the Co-fine of the Ark found is to the Co-fine of the Ark remaining : fo is the Sine of the leffer Latitude to the Co-fine of the distance required.

3. When both Places are without the Equinoctial. and one of them fituate towards the North Pole, and the other towards the South : fay thus, As the Radisus is to the Co-sine of the difference of Longitude : so is the Co-tangent of one of the Latitudes, to the Tangent of another Ark, which being substracted out of the other Latitude, and 90 d. added together: fay again, As the Co-fine of the Ark found is to the Co-fine of the Ark remaining : fo is the Sine of the Latitude first

taken, to the Co-sine of the distance required.

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CAP. IX.

The Use of the Rule of Proportion in Navigation.

ees being known, to find the Meridional Difference.

Hen one of the Places is fituate under the Equino tial, and the other without: The Degrees and Decimal Minutes found upon the Scale of Equal Parts at the Point; where that other Latitude n represented upon the Scale of Latitudes, are the Meridional difference required.

2. When one of the Places have Southerly, and the other Northerly Latitude: Extend the Compaffes upon the Line of Latitude, from the beginning of that Line to the leffer Latitude: that done, if you apply that extent upon the same Line, and the same way from the greater Latitude, the movable Point will discover upon the Line of equal Parts, the Meridional difference defired.

3. When both Places have Northerly or Southerly Latitude: Extend the Compasses upon the Line of Latitudes from one of the Latitudes to the other: this

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done, if you apply that extent from the beginning of the Line, the movable Point will show you upon the Scale of Equal Parts the Meridianal difference you look for.

Probl. 2. The Latitudes of two places tigether with their difference of Longitude being known, to find the

Rumle directing from the one to the other.

As the Meridional difference is to the difference of Longitude: fo is the Radius to the Tangent of the Rumbe: And therefore,

The extent upon the Mean Line of Nambers from the Movidional difference to the difference of Longitude, will reach upon the Line of Tangents from 45 d. to the Tan-

gent of the Rumbe.

And note here, that in this Problem and the like, you may make use of the double Scale, placed upon the last Line of the Rule of Proportion, at the end of the Scale of Inches: viz. (if need be) for the more speedy reduction of the Sexagenary Minutes of the Longitude into Decimal, & centra: to the end you may by that means the more readily work by them upon the Mean Line of Numbers.

Probl. 3. By both Latitudes and Rumbe to find the

distance upon the Rumbe.

As the Co-fine of the Rumbe to the true difference of Latitudes: fo is the Radius to the diffance requi-

red: And therefore,

Extend the Compasses across from the Co-sine of the Rumbe (found upon the Line of Sines) to the strue difference of Latitudes (found upon the Mean Line of Numbers) this done, if you apply that extent the same way and across from 20 d. upon the Line of Sines, the minutes Point will shaw you upon the when Line of Numbers (in Degrees and Decimal Minutes) the distance required.

Probl. 4. By loth Latitudes and Rumbe, to find the

difference of Longitude.

As the Radius to the Tangent of the Rumbe: so is the Meridional difference of the Latitudes to

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The extent upon the Line of Tangents from 45 d. to the

Tangen f the Rumbe, wis reach up n the seem Line of Numbers from the Meridianal difference of the Latitudes to the difference of Langitude required.

Probl. 5. By both Latiendes and distance to find the

Rumbe.

As the diffance is to the true difference of Latitudes: so is the Radius to the Co-line of the Rumbe: And therefore,

The extens up n the Mean Line of Numbers, from the distance to the difference of Line des, we were upon the Line of Sines pour of to the Co-jine of the Rumbe.

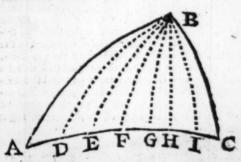
Probl. 6. By ne Latitude, distance, and Rambe, to

find the other Lasitude.

As the Radius to the Co-line of the Rumbe: fo is the difference to the true difference of Latitudes: And therefore,

The extent upon the Line of Sines from 90 d. to the Co-fine of the Rumbe, well reach upon the Mean Line of Numbers, from the distance to the true difference of Latitudes.

Probl. 7. The Latitudes and difference of Longitude of two places being known, to full by the great Circle from the one to the other.



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In the Triangle A, B, C, let A represent S. Chri-Rophers, C, the Lizard, B, the North Pole, A, B, the Complement of the Latitude of S. Christophers, viz. 74 d. 30 m. B, C. the Complement of the Latitude of the Lizard, 40 d. o m. and A, B, C, the difference of Longitude, 68 d. 30 m. Now therefore to fteer a course from A to C alongst the Ark A, C, proceed thus :

1. By the 24 and 25 Problems of the fifth Chapter find the fide A, C, as also the Angles A, and C.

2. By the 22 of the fame Chapter find the Perpendicular B, 7, cutting the fide A, C, at Right Angles.

3. By the 8 of the sime discover the Angle A, B,

I, and by the 9 the fide A. I.

4. Lessening the Angle A, B, I, two, five, or ten Degrees, as you shall see cause, (for Example, by the Angle A, B, d,) by the knowledge of the Angle d, B, I, and of the fide B, I, find by the 11, 12, and 13 Problems of the same fifth Chapter, the Bale B. d, the fide d. I, and the Angle B, d, I; and so proceeding to do the like at the Points e, f, g, and h, you may thereby discover the several distances betwixt Point and Point, the feveral Latitudes at those Points, and the feveral Angles according to which you are to direct your Course: For at hift, from A you are to steer according to the Angle B, A, I, until you shall have fiiled fo many Leagues as answer to the distance betwixt A and d: and then from d, according to the Angle B, d, I, untill you shall arrive at the Point o, according to the number of Leagues that d and e are diffant the one from the other: and so consequently of the rest in their order, until you shall attain the Point I, from whence you are to fleer full West towards c, the Angle B, I, C; being a Right Angle, oc.

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CAP. X.

The Use of the Rule of Proportion in the Gaging of Vessels.

Probl. 1. The true Content of a Solid Measure being known, to find the Gage Point of the same Measure.

The Gage Point of a folid Measure is the Diameter of a Circle, whose Superficial Content is equal to the folid Content of the same Measure so the solid Content of a Wine-gallon (according to Winehester measure) being 231 Cube-inches, if you conceive a Circle to contain so many Inches, you shall find (by the fortieth Problem of the fifth Chapter) the Diameter thereof to be 17. 15: For,

As 1 x to 1.273: So is 231 to 294. 1, whose Square root (by the twelfth Problem of the same Chapter) is 17.

15, the Gage-point of Wine-measure.

Thus likewife may you eafily different the Gagepoint of Ale-measure, an Ale-gallon (as it hath been of late difference) containing 288 Cube-inches: For,

As 1. hto 1. 273: fo h 288 to 366. 7, whife Square-rect is 19.15, the Gage-point of Ale-measure.

And

And (indeed) 288 Cube-inches from to be the most probable Content of an Ale-gallon, being the fixth part of 1728, which is the Number of Cube-inches contained in a Cube-foot. For so (according to that account) a Cube-foot contains just fix Gallons, and the Gage-point of Ale-measure (by reason of the foil and waste) exceeds that of Wine-measure just two Inches.

After the same manner also may you discover the Gage-point of any Forreign measure whatsover, and afterwards by that means come to the knowledge of the true Content of their Vessel, according to the Measures used amongst them, as will plainly appear by that which shall hereafter be taught for the discovery of the Contents of Wine and Beer-vessel according

ing to the English Measures.

Now from that which is above aid doth necessarily follow this Corollary: When the Diameter of a Cylinder in Inches n equal to the Gage-pant of any Measure (given likewise in Inches) every Inch in the length there of contains one Integer of the same Measure: So in a Cylinder having 17.15 Inches Diameter, every Inch in the length thereof contains one intire Wine-gallon: and in another having 19.15 Inches Diameter, every Inch thereof contains one Ak-gallon, &c.

Probl. 2. In a Wine or Beer-veljel, the Diameters at the Head and Bongue being known, to find the required

Diameter.

Extend the Compasses upon the Line of Inches from the Diameter at the Head, to the Diameter at the Bongue: then applying that extent from the beginning of the same Line, and observing there the difference betwixt the two Diameters, (one of the Points remaining still fixed at the beginning of that Line) close the Compasses till the other Point may fall upon so many parts of the Gage-line, as the disserted between the two Diameters, amounts unto in Inches: this done, and that extent applied from the Diameter

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Diameter at the Head towards the Diameter at the .. Bongue, will cause the movable Point to fall upon the

Equated Diameter you look for.

Example, The Diameter at the Head being 18. 3 Inches, and that at the Bongue '21.5 Inches, I demand the Equated Diameter. First, extending the Compasses upon the Line of Inches from 18.3 Inches to 21.5, and then applying that extent from the beginning of the same Line, I find the movable Point to fall upon 3. 2 Inches, viz. the true difference of the two Diameters: Now therefore if still keeping one of the Points of the Compasses fixed at the beginning of that Line, I close them till the other Point may fall at 3. 2 upon the Gage-line, and after apply that extent from 18, 3 (the Diameter at the Head) the movable Point will at last fall upon 20. 54 Inches, the Equated Diameter required. And by this means your Veffel, which before was in part of an Oval form and irregular, is now reduced into a perfect Cylinder.

Probl. 2. The equated Diameter and length of a Wine or Beer-welfel being given in Inches, to find the Centent

there f in Wine-measure.

The extent upon the Line of Numbers from 17.15. (the Gage-point of Wine-measure) to the Equated Diameter, being twice repeated from the length, will reach to the Content in Wine-gallons.

Probl. 4. To find the Content in Ale-menfure.

The extent from 19. 15 (the Gegespoint of Alemeafure) to the Figured Dismeter; being twice repeated from the length, will reach to the Content in

Ale-gallons.

Probl. 5. Having the length and the two Diameters at the Head and Bongue, together with the Equated Diameter and Content of a Vefel, and if wence is much and no more of the liquor is decrease; that the Superficies thereof may cut some part of the Fead, to find the true quantity of the remainder.

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Deduct half the difference of the Diameters at the Head and Bongue, out of the distance intercepted between the Bongue and the Superficies of the Liquor, to the end you may thereby discover where the Liquor within the Vessel cuts the Head, according to which draw a Line with Chalke (or otherwise) upon the Head, then having drawn another Line parallely of the first, and of like distance from the other opposite side of the Head, you have in the middle of the Head betwixt those two Lines a Segment of the Vessel marked out, and likewise two other Segments, the one above and the other below that middle Segment: after this taking the length of one of those Parallels in Inch-measure, the Equated Diameter of the Superficies may be thus found out upon the Rule:

The extent from the Diameter at the Head to the Equated Diameter of the Vessel, will reach from the length of one of the Parallels to the Equated Diameter of the Su-

perficies.

Then having discovered (by the 2d Problem aforegoing) the Equated Diameter of those two other Equated Diameters, find (by the tenth Problem of the fourth Chapter) the Mean Proportional between that third Equated Diameter and the distance between the two Parallels: This done, make use of that Mean Proportional, as an Equated Diameter of the middle Segment, and then finding by one of the two laft Ph-Ulems according to the Question propounded) the Content thereof in Gallons, &c. deduct that Content out of the whole Content of the Vessel: All this performed, when the Veffel is above half full, the Content of that middle Segment and half that remainder being added together, is the Content you look for. But, when the veffel is not half full, half that remainder is the Content defired.

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CAP. XI.

The Use of the Rule of Proportion in Military Orders.

Probl. 1. Any Number of Soldiers being propounded, to order them into a Square Battail of Men.

Find (by the twelfth Problem aforegoing (the Square-root of the Number given: For, look how much that Root shall happen to be, so many Soldiers ought you to place in Rank, and so many likewise in File, to make a Square Battail of Men.

Example; Let it be required to order 573 Soldiers into a Square Battail of Men: the Square-root of that Number is 23.94: and therefore you are to place 23 in Rank, and as many also in File: For; Fractions are not considerable in Questions that concern, Military Orders.

Probl. 2. Any Number of Souldiers being propounded to order them into a double Battail of Mee: viz. which

may have twice fo many in Rank as in File.

Find out the Square-root of half the Number given: for that Root is the Number of Soldiers to be placed in File: and so many more ought to be placed

placed in Rank, to make up a double Battail of Men.

Example, 1342 Souldiers being propoueded to be put into that order: I find 26,5% to be the Square-root of 671 (half the Number propounded) and thereupon conclude that 26 ought to be placed in File, and 52 in Rank, to order so many Soldiers into a double Battail of Men.

Probl. 3. Any Number of Soldiers being given, 20 order them into a quadraple Battail: viz. such as may

have fourtimes so many in Rank as in File.

Here the Square-root of the fourth part of the Number given will shew the Number to be placed in File, and sometimes so many are to be placed in Ranks.

So 2048 Soldiers being offered to be put into that order, 22 are to be placed in File, and 88 in Rank. For, the fourth part of 2048 is 512, whose Square-root is 22, &c.

Probl. 4. Any Number of Soldiers being given, together with their distance in Kank and Eile, to order them

into a Square Battail of Ground.

Extend the Compafes upon the Mean Line of Numbers from the diffance in File to the diffance in Rank: this done, and that extent applied the fame way, and upon the time Line from the Number of Soldiers propounded, will cause the movable Point to fall upon a fourth Number, whose Square-root appearing at the time Point upon the Great Line of Numbers is the whole Number of Men to be placed in File: bywhich if you divide the Number of Men to be placed in File: bywhich if you divide the Number of Men to be placed in Rank.

Example, 2500 Men are propounded to be ordered into a Square Barrail of Ground, in fach fort that their diffance in File being feven foot, and their diffance in Rank three foot, the Ground whereupon they fland may be a just Square. To refolve this Question, extend the Compasses upon the Mean Line

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of Numbers downwards from 7 to 3: then (because the fourth Number to be found in all likelihood will confift of four Figures) if you apply that extent the same way from 2500 in the first part of the sime Line, the movable Point will fall upon the fourth Number you look for, where also you may observe 32, cre. upon the second part of the Great Line of Numbers, which are the Number of Men to be placed in File; again, if letting that Point of the Compasses remain fixed there, you close them till the other Point may reach cros-wife to 1 at the beginning of the first part of the said Great Line of Numbers, that extent being applied the fame way (viz. downwards and acrof.) from 2500 upon the fime Great Line, the movable Point will fall near 75, &c. which are the Number of Soldiers to be placed in Rank.

Probl. 5. Any Number of Soldiers being propounded, to order them in Rank and File according to the reofin of

any two Numbers given.

This Problem is resolved much after the Sime manner trat the last was : For,

As the Proportional Number given for the File is to that given for the Rank : fo is the Number of Souldiers to a fourth Number, whose Rest is the Number f Men to be placed in Rank, by which if you divide the whole,

the Quotiens is the Number to be placed in File.

So if 2500 Soldiers were to be martirlled in fuch order, that the Number of Men to be placed in File might bear fuch proportion to the Number of Men to be placed in Rank, as 5 bears to 12: I fly then, as 5 is to 12, fo is 2500 to another Number, whose Root is 77, or. viz. the Number of Men to be placed in Rank, by which if the same 2500 be divided, the Quotient will be 32, orc. the Number of Men to be placed in File.

CAP. XII.

The Use of the Rule of Proportion in Questions that concern Interest and Annuities.

Probl. 1. A Sum of Money being forborn for a certain time, to find how much it will be augmented at the expiration of the same time, accounting Interest upon Interest, according to a certain rate propounded.

The extent upon the Line of Numbers from 100 l. to the aggregate of 100 l. and the rate added together, being repeated the same way from the Sum given, so many times as there are years in the Question, will at last cause the movable Point to fall upon the Principal increased with the Interest, according to the forbearance and rate propounded.

Example, I defire to know how much 273 !. being forborn for five years will be increased at the expiration of those years according to Interest up-

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on Interest, and the rate of 8 l. per centum: Extend the Compasses upon the great Line of Numberss from 100 to 108: This done, if that extent be repeated five times from 273, the movable Point will at last fall upon 402. I (viz. 402 l. 2 s.) the Principal augmented with the Interest for the forbearance of those five years.

Probl. 2. A Sum of Money being due at a time to

come, to find what it is worth in ready Money.

This is the *Inverse* of the last: for here, if you apply that extent backwards from the Number propounded, so many times as there are years in the Que-

ftion, you shall have your defire.

Example, 402 l. 2 s. being due at the end of five years yet to come, I defire to know how much that Sum is worth in ready Money according to the rate of 8 l. per centum: Extend the Compafies from 100 to 108, as before: And then, if you apply that extent five times downwards from 402. I, the movable. Point will at last fall upon 273 l. the value of 402. I, in ready Money.

Probl. 3. A yearly Rent or Annuity being forborn a certain Number of years, to find what the Arrearages thereof will amount unto according to any rate pro-

psunded.

First discover the principal that answers to the Rent or Annuity in question, then find unto what Sum that Principal will be augmented (according to the given rate) at the end of the Term propounded: This done, if you substract the same Principal out of that Sum, the remainder is the Sum of the Arrearages you look for.

Example, A Rent or Annuity of 12 l. per annumbering forborn 16 years, what will the Arreatages thereof amount unto, they being conceived to increase (as they grow due) after the rate of 8 l. per centum. Here first, to find the Principal that answers to 12 l.say thus: If 8 l. hath 100 l. for his Principal,

Cap.XII.

Principal, what ought 12 l. to have for his? the anfiver will be (by the fourth Problem of the fourth Chapter) 150 l. Having thus discovered the Principal of 12 l. viz.. 150 l. I find (by the first Problem of this Chapter) that the same 150 l. being forborn 16 years will amount (after the rate of 8 l. per centum) to 513. 9, that is 513 l. 18 s. Now therefore if I deduct 150 l. (the Correspondent Principal to the Annuity given) out of 513 l. 18 s. the remainder viz.. 363 l. 18 s. is the Sum of the Arearages required.

Probl. 4. A yearly Rent or Annuity being prepoun-

ded, to find what it is worth in ready money.

First, and what the Arrearages thereof amount unto at the end of the Term propounded, and then what those Arrearages are worth in ready money, which shall likewise be the required price or value

of the Rent or Amuity propounded.

Example, What may a man which is defire us to lay out his money after the rate of 8 l. per centum, afford to give for a Leafe of 12 l. per annum that hath yet 16 years in being? I find (by the last Problem) that the Arrearages of 12 l. per annum, being forborn 16 years, amount then unto 363 l. 18 s. or 363. 9, and I find likewise (by the second Problem aforegoing) that the same 363 l.18 s. is worth in prefent money 106. 2, or (which is all one) 106 l. 4s. I conclude therefore that the value of the Lease propounded (at the rate of 8 l. per centum) is 106 l. 4s.

Here, when the Term of the Annuity begins not presently, but after certain years to come, and what the Arrearages forborn for all that time are worth in

ready money.

So in the Example last premised, if the Annuity of 16 years were not to begin till after the expiration of 5 years; in this case you are to enquire what the Arrearages (viz. 363 l. 18 s. being forborn 21 years, are worth in ready money, which you shall likewise

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find (by the second Problem before cited) to be 72: 3, which being reduced is 72 l. 6 s. the value of the Lease required.

Probl. 5. A Sum of Money being prepaunded, to find what Annuity (to continue any Number of Tears, and

according to any rate given) that Sum win buy.

Take any Annuity at pleature, then find the value of that Annuity in ready money: This done, the Preportion will be as followeth:

As the value found is to the Annuity taken; fo is

the Sum given to the Annuity required.

Example, What Annuity (to continue 16 Years) will 1205 l. deferve, so that the purchaser may gain after the rate of 8 l. per centum? Here, first, I take 12 l. per annum to continue 16 years, and find the value thereof in ready money (by the last Problem) to be 106. 2, or 106 l. 4 s. I say therefore,

If 106. 2 give 12 l. per annum.

What will 1205 l. yield? Facit 171,4 per annum, which being reduced is 171 l. 8 s. I conclude therefore, that 171 l. 8 s. is the Annuity (to endure 16 years) which 1205 l. doth deserve, after the rate of 8 l. per centum.

Deo Laus.

FINIS.

A Catalogue of Mathematical and Sea Books, Printed for, and Sold by Thomas Passinger at the three Bibles on London-Bridge, and William Fisher by the Postern on Tower Hill, and Robert Boulter at the Turk's Head, and Ralph Smith at the Bible in Cornhil, near the Roy-I Exchange. Viz.

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Wingate's Rule

OF

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ARITHMETICK

AND

GEOMETRY:

GUNTER'S LINE

Newly rectified by Mr. Brown and Mr. Ackinson, Teachers of the Mathematicks.

Fitted for all Artists for Measuring and Building.

Whereinto is now also inserted the Confruction of the same Rule, and a farther Use thereof, in Questions that concern

Aftronomy, Dialling, Military Orders, Geography, Interest and Annuities.

London, Printed by R. H. for w. Fisher, T. Passinger, R. Boulter, and R. Smith, 1683.

Thom. Tanner

M

TO MY Worthy Friend,

AND ABLE
MATHEMATICIAN,

Mr. John Collins

OF

LONDON.

SIR.

this City, having divulged the Instrument (whose Ufes I explain in this little Treatise) and discoursed of some of the conveniences thereof, I was given to understand by

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The Epistle Dedicatory.

divers, that if pains were bestowed in on that Subject, the Labour thereis taken might obtain good Reception. This (to say truth) hath given me Encouragement thereof to say somewhat and (having caused it to see the Light) to shelter it under your Protection: Nevertheles you shall pardon me, for that by presuming to procure unto it from thence Credit and Recommendation have expressed a willingness to testife, bow much I am,

Your Servant,

Edmond Wingate.

THE

THE PREFACE

TO THIS

Fife, TRANSLATION.

Mongst the many rare Effects produced by the noble Invention of Logarithmes, the projection of the Rule of Proportion is not the least, which being first discovered by that Learned and Industrious Artist Edm. Gunter (late Professor of Astronomy in Gresham Colledge, London, deceased) was by me (in Anno 1624.) transported into France, and there communicated to most of the chief-

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of being in this form once gained, the Practitioner may then use that way of describing it, which sorts best with his own humor.

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Having thus acquainted you with the occasion of publishing this Treatife, lest I may now expose it to prejudice, give me leave to premise these few Advertisements following: First, therefore, it is desired, that he, who intends to read this Book with profit, should have a proper Genius and Phansie for the Mathematicks, not only ready to conceive Mathematical Notions; but likewise able to wrestle with them, and apt to take pleasure in them: For, De quolibet ligno non fit Mercuriss. Again, it is expected he should be aforehand furnished with competent knowledge in those Sciences, viz. 1. In Arithmetick he ought to be acquainted with the Nature of Numbers, whole and broken, abfoluteand relative; with Numeration,

tion, Addition, Substraction, Multiplication, Division, the Rule of Three, direct and inverse; with the Nature and Extraction of Roots, Square and Cube; And with the right use of Logarithms: 2. In Geometry, to be verst in the Doctrine of Triangles, plain and spherical, and (in some competent measure) to know their nature, together with the way and reason of their dimenfion; As also the dimension of other Geometrical Figures: 3. In Astronomy, Dialling, and Geography, to understand that the Problems which concern them, are refolved by the particular application of the Doctrine of Spherical Triangles to those several Sciences: 4. In Navigation, to be indifferently well read in fuch Authors as have explained that Art, and to be able therein also to make use of the Do-Arine of Triangles: With the knowledge of these things (I say) and

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and the like he ought to be (in some reasonable fort) supplied, that intends to make a right and complete use of this Treatise: For, none (1 prefume) will expect to find an intire Body of the Mathematicks in this fmall Bulk, which is only intended for an Enchiridion or Manuel of fuch Mathematical Rules and Analogies, as may most properly ferve for the resolution of Problems, which may be wrought upon this Instrument: And therefore I wholly refer the Reader for demonstrations and larger explanations of the matters in this Book contained, to the further scrutiny of other Authors; Not doubting but that (upon due perusal hereof) he will find as much inferted, as shall be thought necessary to discover the manifold and exquisite use of the fame Instrument. But here I would not be mistaken, as if I did totally exclude all others, who are not

not prepared with fuch an Univerfal Knowledge in the Mathematicks, from having any capacity at all of understanding this Book; For, if he be only in part acquainted with fome of the abovementioned Learning, he may be able to make use of this Instrument according to that degree of Knowledge which he hath therein; For Example, if he only know Multiplication and Division, this Treatife will instruct him how to multiply and divide upon the Rule, and foin like fort of the rest: Howbeit (as I faid before) if he intend to have an intire understanding of the uses of this Instrument, he must be also furnished with an intire knowledge of all the Mathematicks; because it is subservient to every Branch of those Sciences: And then the conveniency thereof will have fuch Latitude, that it will not be confined to those uses only promifed in the Title of this Book, but likewife

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likewise (by the variety of Rules and Examples therein found) may be readily and fitly applied to other Arts and Professions not there remembred; As namely, in Fortification, the Ingenier may here be taught how to find the Sides of his Polygonical Figures, the Lines of Fortification according to the Rules of that Art, the quantity of Trenches and Ramparts, how to order and estimate the labour and work of Pioners, and the like. The Surveyor also may here furnish himself with divers expeditious dispatches, for the taking of distances, the summing up of Plots, being first divided into Triangles, the distribution of Fields or Lordships to several Persons, the cutting off any part of a Triangle or Plot according to any quantity propounded, &c. The Sc like may be faid of Musick, Archi- co tecture, the Prospectives, Gunnery, &c. ry The Goldsmith also, and Mint-Ma. Pe Aer.

fer may here learn how to temper their Allegations : The Merchant and Tradesman, how to resolve queflions of Partnership, and to cast up the value of their Commodities: The Justice of Peace and High Constable, how to rate a Town, Hundred, or County, &c. All which and much more must be wholly left to the discretion of those, that will take the pains to understand the use of the said Instrument; which (I perswade my felf) no man (affecting the Mathematicks) will think much to undergo, considering the benefit he may reap thereby, and the delight he may take therein; For, by help thereof, and of a pair of Compasses, only fix Inches long, he may refolve with requisite exactness any any Proposition in the Arts and The Sciences above remembred (which chi- comes within the bounds of ordina-ு். ry practice) without the help of Ma- Pen or Paper, and shall thereby also perform

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perform more in one hour, then otherwise (I mean by ordinary A-rithmetick) he shall be able to dis-

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patch in two whole days.

But it may be objected, if this Instrument be of such excellent use as is here pretended, why hath it not been heretofore of greater esteem, it being now above twenty years fince it was first invented? This Objection may be answered divers ways: 1. It is no easie matter to drive men out of their old track, especially when they have entertained an opinion that there can be none better. 2. Again, the use thereof in the point of Numbring upon the Rule (which ought to be accounted the chiefest, and indeed the ground of all the rest) hath not been heretofore (under favour) fo fully explained, as here you shall find it: For, albeit (I confess) it were great prefumption in me to assume to my felf the reputation of having

having better abilities to describe any of the uses thereof, then Mr. Gunter himself had, who first invented it; yet this I can aver upon mine own knowledge, that he did forbear to explain the use thereof, because he took it for granted none would meddle with it but fuch only as were already well able to underfland how to number upon it, having before-hand acquainted themfelves with the manner of Numbring upon Scales, and with the nature of Logarithms: For, when after my return out of France, I importuned him to make a fuller explanation, how to number upon it, to the end the use thereof might by that means be made more publick, his answer was, That it could not be expected the Rule should speak; Intimating thereby, that the Practitioner should (in that point) rely much upon discretion, and not altogether depend upon Precepts and Examples. But lastly,

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o f The Preface.

ly, the chiefest causes why this In ing strument hath been hitherto obscu- No red and the uses thereof no better and known to the World, are thefe too 1. The Difficulty of describing the the Lines thereupon with convenient est exactness: 2. The trouble of work- ex ing thereupon by reason (some that times) of too large an extent of the thi Compasses: 3. The importableness ve thereof, it being requifice for work- Ining upon fuch a Rule (only two foot ye long) to use a pair of Compailes of up nine Inches: 4. The charge of par- ar chasing such an Infirm ent made of on Brass or Wood; For, none but let fuch have been heretofore used per For remedy of the first of these, i if have caused the Plate, whereupon use this Instrument is Printed, to be up protracted with a great deal of care w and circumspection, so that I dare co affirm it to be as exactly drawn (for present the main and most considerable Divisions thereof) as may be expect-

ed

The Preface.

ed from Art: For the fecond, hav-In ing there three several Lines of Cu. Numbers by degrees one less than ter another, when the Compasses are too little for one, you may use anothe ther, also Croß-work upon the greatent est Line will prevent the too great rk. extension of the Compasses; fo ne that it will be requisite to use with the this Instrument (as it is now contriness ved) a pair of Compasses only six rk- Inches long, as I faid before; and oct yet the Divisions of this (I mean upon the great Line of Numbers) are near as large again, as those upof on Mr. Gunter's Rule of the like but length: The third and fourth imfed pediments may also be remedied, e, i if in stead of Brass or Wood you pon use the impression of the said Plate be upon Vellum or Imperial Paper, care which may either be rolled up and dare couched in a little Box, or otherwise (for pasted upon a Ruler either flat, to Di- use at home, or round, to be carried ect-

The Preface.

in a hollow Staff or Cane together with the Compasses, which are to be used therewith. Also divers useful conveniences shall you meet withall in this Edition of the Rule; as namely, a readier way of finding out Mean-Proportions, the Extraction of Roots by Inspection only, without aid of Pen or Compasses, and the like: For further discovery of all which I refer you to the Book it felf, hoping that my real intention to advance the Publick Good will procure from the Ingenuous Reader a favourable construction of what he shall therein find not wilfully mistaken.

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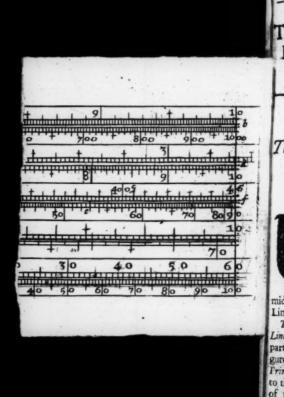
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A T Cherry-Garden Stairs on Rotherhith Wall, are taught these Mathematical Sciences, viz. Arithmetick, Geometry, Algebra, Trigonometry, Navigation, Dialling, Assertion, and Gunnery; The use of the Globes, and also other Mathematical Instruments; likewise the Projecting of the Sphere, or any Circle, &c. And other Parts of the Mathematicks, and Merchants Accounts.

By James Atkinson.





THE USE OF THE Rule of Proportion in Arithmetique and Geometrie.

CAP. I.

The Description of the Scales projected upon the Rule of Proportion.

Pon the five Lines of the Rule of proportion, there are ten several Scales projected, viz. two upon each common or middle Line, the one having the Divisions thereof shooting downwards, the other upwards: So the first two Scales meet upon the

middle or common Line a, b, the next two upon the Line c. d, &c.

The uppermost or fift Scale of the Rule is a single Line of Numbers; first divided into nine unequal parts, called Primes, and distinguished by the Figures, 1.2.3.4.5.6.7.8.9. And then, each of those Primes, subdivided into ten other Parts (according to the same Reason) called Tenths: And again, each of those Tenths subdivided, or at least supposed to be subdivided into ten other Parts, as the length of

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the Rule will admit: For Example, upon the Scho of our Rule (hereunto annexed) which is fuppo to be about two foot and three inches long between the end-lines in the four first Primes (viz. between the Figures 1 and 5) each Tenth is really subdivide into ten Parts; but in the rest of the Primes (viz.) tween the Figure 5, and the end of that Scale) of Tenth is divided but into five Parts; and there each of those five Parts ought to be efteemed have the value of 2; and the faid tenth parts those Tenths are hereafter called Centefmes : Last each of those Centesmes is also supposed to be sub vided into ten leffer Parts, which are hereaftere ed Millains: By all which you may observe, the the longer the Rule is, the more small Division will admit, and the shorter it is, the fewer.

The fecond Scale is another Line of Numbers thrice peated: This Scale shoots upwards upon the Comon Line a, b, and being of a lesser Volume the former, must in some Parts thereof contenties with less Divisions, viz. from the Figure of s the end of that Scale the Tenths are only division two Parts, and therefore each of those Parts ought to retain the value of five: All three Parts of this Scale being taken together, a hereafter (for distinction sake) called the Little Lof Numbers, and are in their use distinguished by first, second, and third Part, as they lie in ord They are also of singular use for the ready discom of the Cube-root, and for the resolution of others cessary operations, as shall be shewed hereafter.

The third Scale is the first Scale repeated, taking beginning from the middle of the Rule, and being had off at the upper end thereof, is afterwards continued for the lower end of the same to the place where it first began This Scale abuts downwards upon the Communities c, d; and the first and this being taken too there are hereafter called the Great Line of Number

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whereof the first Scale is called the first Part, and this the fecond.

The fourth Scale is another Line of Numbers tovice repeated: This Scale shoots upwards upon the Common Line c, d, and being intirely taken together, is hereafter called the Mean Line of Numbers: It confifteth also of two Parts, distinguished by first and fecond, as they lye in order; and is of necessary use for the finding of the Square-root, and of

mean Proportions, as shall appear hereafter.

The fifth Scale is a Line of Tangents; This Scale abuts downwards upon the common Line e, f, and doth first contain the Artificial Tangents of the Quadrant from o. degr. 35. min. to 45. degr. at the upper end of that Scale, and so if the Rule would permit, should they be continued forward to 89. degr. 25 min.but because the Divisions of that Scale being inverted, will fall out to be the same with the former, they are to be noted and accounted backwards from 45. degr. at the upper end of that Scale to 89. degr. 25. min. at the lower end of the same; each degree thereof being fubdivided into fix Parts, and each of those fix Parts supposed to contain ten minutes.

The fixth Scale is a Line of Sines : Upon this Scaleshooting upwards upon the Common Line c, f, are described the Artificial Sires of the Quadrant from o. degr. 35. min. to 90. degr. at the upper end of that Scale, each degree (upon our Rule) from o. degr. 35. min. to 30. degr. being subdivided into fix Parts, each Part representing ten minutes, as those of the Tangents; but from 30. degr. to 50. only into four Parts, each Part containing 15 minutes; from 50 to 70, into two Parts, each Part comprehending 30 minures; from 70 to 85, into eaven degrees; and laftly. from 85. degr. to 90, not divided at all, but supposed to be divided into five Parts, reprefenting those five last degrees of the Quadrant.

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The feventh Scale shooting downwards, is the who See Rule divided into 1000 equal Parts; It is hereafted called the Scale of equal Parts, and is of use for the Construction and Fabrick of the Great Line Numbers.

The eighth Scale shooting upwards, is a Scale of a degr. II min. of the Quadrant described according Mercator and Mr. Wright's Projection: It is hereafted called the Scale of Latitudes, and is to be used together with the Scale of equal Parts; and both of the taken together, are usually called the Meridian Line and are of excellent use in Navigation, as shall be declared hereafter.

The ninth is the Scale of Inch-measure, viz. two for thereof divided into 24 inches, and each inch int ten lesser Parts, counted both forwards and back

wards, after the usual manner!

The tenth and last Scale consists of three several kind viz. a Gage Line, a Line of Cords, and a Scale of Formeasure: The first of these being signed by the Les zer G, is nothing else but seven inches divided into ten equal Parts, and those subdivided into ten lesse Parts, and is hereafter to be used for the ready disco very of the equated Diameter (and to by confequent of the Content) of any Wine, Beer, or Oyl Veffel: The next marked by the Letter C, is an ordinary Line of Cords, already fufficiently known, and of frequent use amongst Artists; the third and last marked by the Letter F, is the Scale of Foot-measure being nothing else but a foot first divided into ten Parts, and those subdivided into ten leffer Parts, and to (by confequent) the whole foot supposed to ke thereby divided into 1000 Parts.

At the end of these two Scales there is another double Scale placed, containing in length three inches French, whereof the uppermost shooting downwards, is a Scale divided into 60 Parts, and that shooting upwards into 100 Parts: The use of

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ap. These two Scales is for the ready reduction of Sexabe not genary minutes to Decimals, and of Decimal minutes for Sexagenaries, as shall appear hereafter.

CAP. II.

The Construction and Fabrick of the Lines described upon the Rule of Proportion.

1. 7 0 describe the Line of Numbers, having prepared a Rule of Silver, Brass, or Wood, (of what length you please) and caused it to be ruled according to the Pattern hereunto annexed, and also a Scale of 1000 equal Parts to be drawn, equal in length to your intended Line of Numbers, repair to the Table of Logarithms , and therein observing the first four Figures of the Legarithm of 101, beside the Index or Charafteristick (viz. 0043) take with your Compasses the distance from the beginning of the Said Scale of equal Parts to the Said 43 Parts; This done, if you apply that extent of the Compasses upwards, from the beginning of the Line of Numbers, which you intend to make, the moveable Point of the Compasses, will fall upon the first Centesme of that Line: In like manner by the first four Figures of the Logarithm of 102, besides the Index (viz. 0086) you may mark the second Centesme of the same Line, and so consequently all the rest in their order. Example, If it were propounded to make a Line of

Numbers equal to that of the first Scale, let there be

a Scale of equal Parts made, equal in length to

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that Line, fuch as the feventh Scale before de Scale, scribed happens to be: then extending your Com-the ret railes from the beginning of that Scale of equal parts of i'arrs to 0043, viz to the Point a, apply that extent leach of from the beginning of your Intended Line of Numbars; For, that done, the moveable Point of the "Compasses will fall upon the first Centesm of that · Line, viz. at the Point e: In like manner, the extent from the beginning of the Scale of equal Parts to 0086, viz. to the Point c, will mark out upon the intended Line of Numbers the Point b, representing the Good Contelm of that Line, and to confequently the

2. The Line of Tangents is framed much after the tame manner; For, having before prepared a Scale of equal Parts farable to that Line, (viz. confifting of half the length of the whole Line) Repair unto the Table of Artificial Sines and Tangents, and therein finding the Artificial Tangent of o. degr. 40. min. if (rejecting the Characteristick or first Figure thereof) you take off with your Compasses upon your ferefaid sutable Scale of equal Parts (as before) she four first Figures of the same Tangent (viz. 0658) that extent being applied appeards from the beginning of the Line of Tangents, will canse the moveable Point of the Comp. ffes to fall upin the Division, representing o. degr. 40.min. In like manner the extent of 1627 (the fecond, third, fourth, and (file Figures of the Tangent of o. degr. 50. min.) will guide to mark out the fame o. degr. 50.min. upon the fame Line : And so proceeding you may readily describe all the relt, as they follow in order.

3. The Line of Sines may be drawn in all Points, as the Line of Tangents, if you use the second, third, fourth and ofth Figures of the Artificial Sines, as you are before directed to use those of the Tangents. And here note, that the Line before called the Mean Line of Numbers, and these Lines of Tangents and Sines are all of them framed by one and the same

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de Scale, and are also hereafter to be used together in Com-the resolution of Plain Triangles, the Scale of equal equal Parts or Radius, by which they are made, being in each of them twice repeated. ctent

4. The Meridian Line being framed by the ordipary Table of Meridional Degrees, and the making of the Line of Cords being obvious to every mean that | Practitioner in the Mathematicks, I shall not need to rouble you with their Confirmation. The other Scales alfo, which confift of equal Parts, will not need any farther description.

CAP. III.

Numeration upon the Rule of Proportion.

PROBL.

Awhole Number being given, to find the Point where the same is represented upon the Line of Numbers.

I Ind amongst the Figures, by which the Primes are distinguished, the first Figure of the Number given, and for the second Figure there f count from the beginning of the Prime, unto which the first Figure directs you, so many Tentles as that Figure hath Unites; Then for the third Figure count from the last Tenth so many Centesms as that third

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third Figure hath Unites: And fo likewife for the for Figure count from the last Centefme fo many Millain 2000 the Same fourth Figure bath Unites : This done, you al lift fall upon the Point where the Number propoun is reprejented upon the Line of Numbers.

Example, The Number given being 1728, the at th Figure thereof (viz. 1.) leads me unto the first Pri 3000 detigned by the Figure 1, within which Prime cou have ing feven Tenths for the fecond Figure, and from ning Geventh Tenth two Centelmes, for the third Figu Tenth and from the second Centesme eight Milains for t fourth Figure; at last I find the Number given to represented upon the first Part of the Great Line the l Numbers at the Point h: So likewife is the Numb 27 found at the Point k, the Number 542 att Point 1, and 3345 at the Point m, &c.

From hence follow these Corollaries:

1. The Figure which any Number given hath towar the right hand, besides the first four Figures towards left hand, are not expressed upon the Rule: And therefo if the Number given were 172845, it would be lik wife represented at the Point h: Howbeit, that u certainty caufeth no inconvenience in the use of the Rule, as shall more plainly appear hereafter.

2. The Figures by which the Primes are distinguish (in reference to one and the same Number) retain alms

one and the same value.

Example, In searching the Number 1728, concein ing the Figure prefixed at the beginning of the fit Prime (viz. 1.) to have the value of Thousands, the F gure prefixed before the second Prime (viz. 2.) ough also to be esteemed to have the value of Thousand lo and fo of the rest in their order: for, according to the same reason that h represents 1728, the Point will represent 2000, the Point p 3000, &c.

3. The Numbers, which have only the simple value a Thites as 1.2.3, 4. &c. and thefe which after the fin

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the for Figure have nothing but Cyphers, as 10.100.1000.20.200. you 12000. &c. are all represented at the same Points.

So 1.10.100.1000. c.may be all represented at the repoun beginning or end of the Line 2. 20. 200. 2000. cr. the set the beginning of the fecond Prime: 3.30.300. At Pro 3000. &c. at the beginning of the third Prime, &c.

4. The Numbers, which being composed of three Figures ae cour have a Cypher in the middle, are found betroixt the beginfrom Fig ning of the Prime, unto which they belong, and the first Tenth of the Same Prime. for :

So. 405 beginning by the Figure 4, (and therefore Line to be fought for in the fourth Prime) is represented at Numb the Point o.

5. The Numbers, which being comp fed of four Figures, have now Cyphers in the middle, are represented betroixt the beginning of the Prime, unto which they belong, and the first Centesme of the same Prime: So 1005 is found towar at the Point q.

6. When the Line of Numbers is repeated, and for that cause consisteth of several Parts; the first Part there f is in value a degree less than the second, and the second a debe lik gree les than the third, &cc.

So upon the Mean Line of Numbers, if you corceive 10 at the upper end thereof to represent 100. the Figure 1 in the middle (or which is all one, at guish the beginning of the fecond Part) will represent to. alma and I at the lower end of that Line (or which is all one, at the beginning of the first Part) will represent oncei 1: But if 10 at the upper end thereof shall be conne fin ceived to bear but the value of 10, the Figure 1 in the F the middle shall have the value of one, and one at the lower end the value of ray and 2 the value of ray usant ling a er. In like manner, if to at the upper end represent 'oint I, the Figure I in the middle must represent value and I at the lower end Tob, &c.

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PROBL. 2.

To find a Fraction or broken Number upon the Line of Numbers.

The Fractions, which are to be found upon the Line of Numbers, ought always to be Decimals, viz. ought always to have for their Denominators the Figure 1, with nothing but Cyphers towards the right hand, such as are \frac{125}{1000} \frac{25}{1000} \frac{5}{1000} \frac{77}{1000} \frac{

PROBL. III.

To find a Mixt Number upon the Line of Numbers.

First find by the first Problem aforegoing the Peint representing the whole Parts of the Number given, and then afterwards the Fraction or broken Parts there f in the Ranks that follow.

Example, a Line that hath the length of 17 foot and 28 of a foot (which may more conveniently

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be written thus, 17, 28) being propounded; first, I find the whole Parts thereof, viz. 17) represented at the Point r, and after counting two Centesins, and then eight Millains, at last I find the Number given to be represented at the Point h. In like manner if the Number propounded were 172. 8, or 1.728, in would be still represented at the same Point.

PROBL. IV.

Any Point of the Line of Numbers being assigned, to find the Figures represented at the same Point.

The the Pigure prefixed at the beginning of the Prime, within which the Point is propounded, for the first of the Figures required; then shall the second Figure required be composed of so many Unites as there are Tenths, intercepted between the beginning of the same Prime and the Point given. In like manner shall the third Figure required have so many Unites as there are Contesms comprehended between the last of those Finths and the said Point: And so likewise shall the fourth Figure consist of so many Unites as there are Millains between the last Centesm and the Point given.

Example, If the Point h were propounded, because that Point is fituate within the Prime, before which the Figure 1 is prefixed, I take the Figure 1 for the first of those required; and then finding seven Tenths betwixt the beginning of that Prime and the Point given, I set down 7 for the second: And so proceeding and finding two Centesius betwixt the last Tenth and the said Point, I take 2 for the third Figure: And lastly; conceiving eight Millains to be comprehended between the last Centerior

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refine and the Point given, I take 8 for the four Figure required: This done, I conclude, that the Figures represented at the Point propounded, at 1728. In like manner the Point q being given, I take I for the first Figure; but here because I sind to Tenths betwirt the beginning of that Prime and the Point given, I write a Cypher in the second place and there also finding no Centesines, I write also Cypher in the third place; And then at last finding the Point propounded in the middle of a Centesine (which is supposed to be divided into the Millains) I annex in the fourth place 5: This done the Figures represented at the Point given will be found 1005.

PROBL. 5.

An Ark or Angle being propounded to find upon the Rule of Proportion the Point which represents the Tangent of the same Ark or Angle

If the Ark or the measure of the Angle exceeds not 45 degrees, search the degrees of that Arke or Angle upon the Line of Tangents, mounting upwards from the lower end of that Line towards the upper end of the same.

So the Tangent of an Ark or Angle, which confifts of 15 degrees, is represented at the Point 4: of

25 degrees at the Point b, &c.

But if the Ark or measure of the Angle exceeds 45 degrees, look the degrees thereof, descending downwards from the upper end of the Line towards the loveer end of the same: So the Tangent of 65 degrees is found at the

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the Point b, of 75 degrees at the Point a, &c. And if the Arkor Angle propounded (besides the phole degrees) is also composed of certain minutes, find first the whole degrees , and after that , bet wixt the last degree found, and the next that follows, take so many of the Parts which may amount to the minutes given accounting each of the Parts contained between the two degrees for ten minutes: So the Tangent of 22 degr. 45 min. is found at the Point d, and the Tangent of 72 der. 45 min. at the Point a. And therefore e converso, if the Points d'and t were given upon this Line, the degrees and minutes represented by them, would be 22 degr. 45 min. and 72 degr. 45 min. &c.

PROBL. 6.

An Ark or Angle being propounded, to find upon the Rule of Proportion the Point, which represents the Sine of the same Ark or Angle.

Ind upon the Line of Sines the degrees of the Ark or Angle given, and you have your defire: So the Sine of the Ark or Angle of 22 'degr. is represented at the Point r.

But if the Ark or Angle given have also minutes annexed, first fearch the whole degrees given, and then between that degree found and the next that follows, take so many Parts as you have minutes propounded, conceiving the distance betwixt each degree, and the next that follows to comprehend 60 minutes.

So the Sine of 22 degr. 45 min. is found at the Point #; of 42 degr. 50 min. at the Point q; of 52 degr. 45 min. at the Point c, &c. And therefore here

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allo e converso, if the Points u, q, and e were affigned upon this Line, the degrees and minutes reprefented by them would be 22 degr. 45 min. 42 degr. 50 min. and 52 degr. 45 min. &c.

CAP. IV.

The use of the Rule of Proportion in Arithmetick.

N Arithmetick there are three several forts of Proportion, Arithmetical, Geometrical, and Mu-Arithmetical, when divers Numbers being compared together retain amongst themselves equal differences, as thefe, 2. 4. 6. 8: &c. And this is either continued, as in the Numbers before produced, or in these, 3. 6. 9. 12. 15, &c. which is also called Arithmetical Progression, or a Rank of Numbers Arithmetically proportional; or discontinued, as in thefe, 2. 4. 10. 12, or the like. Geometrical Proportion is, when divers Numbers being compared together differ amongst themselves according to the same rate or reason, as these, 2. 4. 8. 16. &c. For here, as 2 is half 4, fo is 4 half 8, and 8 half 16: this is likewife either continued, as in those before propounded, or in these, 1. 3. 9. 27. 81. &c. or the like, which is also called Geometrical Progression, or a Rank of Numbers Geometrically proportional: Or discontinued, as in thefe, 2. 4. 16. 32; for as 4 is double 2, fo is. 32 double 16, but fo is not 16 being compared with 4. Mufical Proportion is that which doth as it were proceed from both the former, as when three. Numbers or Terms being propounded, the first bears the same Proportion to the third, that the difference betwixt

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betwixt the first and the second bears to the difference betwixt the second and third, as in these, 3. 4. 6, for here, as 3 is half 6, so is 1, the difference betwixt 3 and 4, to 2, the difference betwixt 4 and 6. So likewise 2. 3. 6. and 10. 16. 40. are said to be Numbers Musically proportional: For, in the first of these two last Examples, as 2 is to 6, so is 1 to 3, And in the others, as 10 is to 40, so is 6 to 24. Thus have I here thought sit briefly to remember the Resider of the several kinds of Proportion, which he doth usually find in the Writings of those that treat of Arithmetick; to the end that the Problems which follow both in Arithmetick and Geometry may be the better understood.

PROBL. 1.

Two Numbers being given, to find a third Geometrically proportional unto them, and to three a fourth, and to four a fifth, &c.

Extend the Compasses upon the Line of Numbers from one of the Numbers given to the other; this done, if you apply the same extent (upwards or downwards) from either of the Numbers propounded, the moveable Point of the Compasses will fall upon the third proportional required: And so the same extent being applyed the same way from the third, the moveable Point of the Compasses will fall upon the fourth proportional, and from the fourth upon the fifth, &cc.

Example, Let it be propounded to find a third proportional to these two Numbers 2 and 4, which may bear the same Proportion to 4, that 4 bears

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to 2; First, I Extend the Compasses upon the first if t Part of the Mean Line of Numbers from 2 to 4 this done, if I apply that extent outright from 4 up wards, the moveable Point of the Compasses will fall upon 8 the third Proportional required; and being applied the same way from 8, the movable Point will rest upon 16, the fourth Proportional and from 16 to 32, the fifth; and from 32 to 64 the fixth Proportional. But now if you would ye continue the Progression farther, and so find the next Proportional to 64 (because the movable Point in that case will fall beyond the Line) apply that extent the sime way from 64 in the first Part of that Line ; which done , the movable Point of the Compasses will then fall upon 128, the seventh Proportio nal; and so proceeding farther you may find 256, the eighth 3512, the ninth, &c.

Contrariwife, if it were required to find a third Proportional to the same Number 2 and 4, which may bear the same proportion to 2, that 2 bean to 4; extend the Compasses upon the second Part of the Mean Line of Numbers from 4 to 2 downwards; this done, if you apply that extent from 2 the fame way (viz. downwards) the movable Point will fall upon 1, the third Proportiona required;

And from I upon 10 or .5, by the last Corallary of the third Chapter, and from .5 to .25, by the fame Corallary, &c.

In like manner, if the two Numbers given were 10 and 9, the Compasses being extended downwards from 10 at the upper end of the same Line of Numbers to 9, and that extent applied from 9 the same way, the movable Point of the Compasses will rest upon 8 .1, the third Proportional (for the given Numbers being 10 and 9, common fense tells me that it cannot be 81, and therefore ought to be 8.1) and from 8.1 the movable Point will fall up-

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on 7.29, the fourth Proportional, &c. So likewife ne first if the Numbers propounded were 1 and 9, conceiving t0 4 to at the upper end of the Line to represent 1, ex-1 4 up tend the Compasses from thence to 9, which extent s wil being applied downwards from 9, will cause the ; and movable Point of the Compasses to fall upon 81, ovable the third Proportional, and from 81 upon 729, ional the fourth Proportional, &c. And therefore note to 64 hence, that I at the beginning, I in the middle, ild ye and 10 at the end of the Line, are all arbitrary d the Points, and may each of them represent sometimes Point 1, fometimes 10, fometimes 100, fometimes 1000, at exoc. as the terms by which you are to work, shall f that require, according to the third Corollary of the Comthird Chapter. ortio-

Neverthelets neither do the Examples before pro-6, the duced, nor those, which shall follow in the ensuing Problems at all cross that which hath been formerly taught in the second Corollary of the third which Chapter: For, in the last Example, the end of the bean Line in regard of the first term given (viz. 1) hath the fingle value of an Unite; but in respect of the second term o it challengeth the value of 10; and in reference to the third Number 81, the value of

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Laftly, if the Numbers given were 10 and 12, the third Proportional upwards would be 14.4, the fourth 17.28, &c. and the Number 1 and 12 being propounded, the third Proportional upwards (as be-

fore) will be 1443, the fourth 1728, &c.

The like Operations may be also performed (and that much more exactly) upon the great Line of Numbers: For Example, I and 4 being given, I defire to know a third, a fourth, a fifth, &c. Geometrically Proportional: To perform this, extend the Compasses upon that Line across from I at the beginning of the second Part thereof unto 4 upon the first part of the same; which done, that extent be-

Cap.Iv.Cap ing applied the same way, (viz. upwards and acros) 3. will reach from 4 upon the first l'art, unto 16 upon plied, the second, and from thence to 64 upon the first wards Part again, Oc. Line o the up

PROBL. 2.

One Number being given to be multiplied by another Number given, to 45 br find the Product. plying paffes

Xtend the Composses upon the Line of Numbers from the n I unto the Multiplicator ; This done, if you apply requir that extent the same way from the Multiplicand, the moveable Point of the Compifes will fall up.n the ples, ?

Product required.

1. Example, Let the Multiplicator given be 25, fes to and the Multiplicand 30: Here if you extend the it is Compasses upon any of the Lines of Number from I top o into 25, and then apply that extent the fame way cordi from 30, the moveable Point of the Compasses will take fall upon 750, the Product required. So 1. 728, and Operation 25. 6 being propounded to be multiplied, the Pro- on, 40 duct will be found 44. 2. the le

2. Example, The two Numbers given being 45 and 25, I extend the Compasses upon the second A Part of the Mean Line of Numbers from I to 25; as a Then (because, if I apply that extent the same way are n from 45 upon the same Part of that Line, the move Geom able Point will fall beyond the Line) I apply the give same extent the same way from 45 in the first Partisen thereof; which done, the movable Point will fall fourt upon 1125, the Product defired: So the two Numfor t bers given, being 1.728, and 64.5, the Product re Rule

quired will be 111.4.

3. Example, .

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cros 3. Example, If 75 and 35 were given to be multiupon plied, the Compasses ought to be extended downinfluents from 1 to 75, in the first Part of the Mean
Line of Numbers, or (which is all one) from 10 at
the upper end of that Line to 75; for, that extent
being applied the same way from 35, will cause the
movable Point of the Compasses to fall upon 2625,
the Product required.

4. Example, If it were required to find the Content of a piece of Ground 8.75 Perches long, and 6.

10 45 broad; because this question is resolved by multiplying the length by the breadth, I extend the Compasses from 10. at the top of the Line to 8.75; then applying that extent the same way from 6.45, from the movable Point will fall upon 56.4, the Content apply required, viz. 56 Perches and 5; or 4 of a Perch.

And here you may observe, that these last Examin the last, and those that are like unto them, may likewise
be performed in working apparents; But in such cae 25, se to shun too great an extent of the Compasses,
d the it is better to begin the Operation from 10 at the
comit top of the Line, and so to descend downwards according to the instructions before delivered: For,
is will (take this for a General rule, once for all, that) All
B, and Operations, which are wrought upon the Rule of Preportion, are best performed, when the legs of the Compasses have
the least extension.

Again, because this Problem of Multiplication, 25; as also (for the most part) all the rest that follow, was are resolved by the finding out of a fourth Number nove Geometrically proportional to three other Numbers y the given, we will therefore here insert this other Advergantisment: Whensoever question is made of finding a series of the fourth proportional to three such Numbers given, wun-for the better conveniency of working upon the Stree Rule, the order of the second and third terms may be changed, so that always care be taken, that the simple.

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first Number may still retain the first place: F. Ca Example, you may fay, as 1 is to 25, fo is 30 to 750 divid or as I is to 30, fo is 25 to 750. And this Ruk dow diligently to be observed in Multiplication, Dinthe fion, the Rule of three direct, the refolution of thall Plane and Spherical Triangles, and generally in Questions of such like Proportions; to the end the in working upon the Rule of Proportion we may a ways avoid too great an exention of the Compasse and by that means perform the Work the more actly.

Laftly, here observe, that Multiplication, and other Questions hereafter produced, which may be wrought upon the Mean Line of Numbers , m likewise be performed upon the Great Line of Nun bers (and that much more exactly) by working of ther outright or across, as the Questions propounds shall require; which (I well hope) I may hereaft leave to the difcretion of the ingenious Reader discover, without any further instruction, they bein (indeed) but one and the fame Instrument represent

in differing postures.

PROBL. 3.

A Number being propounded to be d vided by another Number, to fin oug the Quotient.

for Kend the Compasses upon the line of Numbers for bec the Divisor to 1; This done, if you apply that of tent the Same way from the Dividend, the move den Point will fall upon the Number of the Quotient. Exa I. Example, Let 750 be the Number given to wh

divide 122

0 750 divided by 25, the Divifor: I extend the Compaffes Ruk downwards from 25 to 1; then applying that extent Dir the fame way from 750, at last the movable Point will of the fall upon 30, the Quotient required.

in a 2. The Number 1125 being given to be divided and the by 25; I extend the Companies downwards from 25 may 2 to 1, then applying that extent the same way from mass. the movable Point will fall upon 45, the Quotiore of ent required. The same Quotient will also be found, and if changing the terms you first extend the Compasses from 25 to 1125, and then apply that extent from may 1; for so also shall the movable Point fall upon 45, Num as before; according to the observation made in the king o pounded, to be divided by 1.728, the Quotient will ounder be found 64.3.

3. The Number 2625 being propounded to be ader; divided by 75; extend the Compaffes upwards y bein from 75; in the first Part of the Mean Line of essent Numbers to I, or (which is all one) from 75 in the fecond Part thereof to 10 at the top of the Line; This done, if you apply that extent the same way from 2625, the movable Point will from thence reach to 35, the Quotient required: So likewife 56. 4 being given to be divided by 8.75, the Quotient

be di will be 6.45.

Now to discover of how many Figures any Quotient fin ought to confift, it will be necessary to observe how many times the Divilor may be written under the Dividend according to the Rules of Division; for, of fo many Figures shall the Quotient be composed: for Example, 12231 being given to be divided by 27; that of Division) be written three times under the Divimove dend 12231 (as may appear by this

en to Example) I say, that the Quotient, which is produced by the Division of divid 12231 by 27 consists of three Figures

12231 27 . .

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For, having extended the Compasses downwards the second Part of the Mean Line of Numbers for 27 (the Divisor) to 12231 (the Dividend) and plied that extent the same way from 1, the morable Point will fall in the first Part upon 453, 2 Quotient of 12231 divided by 27.

PROBL. 4.

To three Numbers given to find fourth in a direct Proportion.

E Xtend the Compasses from the first Number or To given, unto the second; which done, that extent ing applied the same way from the third To will cause the movable Point to fall upon the for

Term required.

Example, If the circumference of a Circle, wh Diameter is 7, be 22; what circumference will Circle have, whose Diameter is 14? Extend to Compasses upwards upon the Mean Line of Numbers from seven in the first Part thereof, unto 14 the second; This done, that extent being applied to same way from 22, will make the movable l'oint aupon 44, the circumference required.

Or otherwise downwards; The circumserence a Circle being 22, and the Diameter thereof 7, he much shall the Diameter of a Circle be, whose counserence is 44? Extend the Compasses downwards from 22 in the second Part, to 7 in the simulation which done, that extent being applied the saway from 44, will reach to 14, the Diameter sou

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PROBL. 5.

To three Numbers given, to find a fourth in an inversed Proportion.

E Xtend the Compasses upon the Line of Numbers from the first of the Numbers given to the second, having both the same Denomination ; this done, if that extent be applied quite backwards from the third given Number, the movable Point will fall upon the

fourth Number you look for.

Example, If 60 Pioners can make a Trench of a certain length and breadth in 45 hours, how long d Ten will it be before 40 men can make fuch another? Extend the Compasses from 60 to 40 (those Terms having both the same Denomination, viz. of men.) This done, that extent being applied backwards from 45, will reach to 67. 5, the fourth Number you look for; I conclude therefore that 40 men will perform as much in 67 hours and an half, as 60 men will do in 45 hours.

PROBL. 6.

To three Numbers given, to find a fourth in a double Proportion.

He use of this Problem appears chiefly in Proportions of Lines to Superficies, or of Superficies to Lines.

NOW

Now if the Denomination of the first and second If terms be of Lines, Extend the Compasses upon the Ladenor of Numbers, from the first term to the second; this domline that extent being applied twice the same way from them, third term will cause the movable Point to fall upon to from fourth term required. to fa

Example, If the Content of a Circle whose Die if meter is 14 inches, be 154, what will the Conte weig of a Circle be, whose Diameter is 28 ? Here I Iron and 28 having the same Denomination (viz. of Line Com I extend the Compasses from 14 to 28; then apply applie ing that extent the Sime way from 154, the movable P Point will first fall upon 308, and from hence upo 36, a

616, the Content defired.

But if the first two terms have the Denominan of S on of areas or Contents, and the quasium be a Lin pase this is the Rule: Extend the Comp sses upon the Mea Term Line of Numbers from the first term to the second; thathe ! done, that extent being applied the same way upon the third Great Line of Numbers from the third term, will can to fal the movable Point to fall upon the fourth term required. If Example, If the Diameter of a Circle, whose arm inches

is 154, be 14; what Diameter will a Circle have weig whose area is 616? Extend the Compasses upon the upon Mean Line of Numbers from 154 to 616; which that done, that extent being applied the same way upon upon the Great Line of Numbers from 14, will reach the n

28, the Diameter required.

PROBL. 7.

To three Numbers given, to find Bet fourth in a tripled Proportion.

The use of this Problem appears in the proportion on of Lines to Solids, & contra.

fecon If therefore the first and second Terms have the he Ladenomination of Lines, Extend the Comp see upon the standard of Numbers from the first Term to the second; this com the die, and that extent applied three times the same way ponts from the third Term; will cause the movable Point at last

in fall upon the fourth Term required.

Di If an Iron Bullet, whose Diameter is 4 inches, onter weighing 9 pounds, what is the weight of another re Is Iron Bullet, whose Diameter is 8 inches? Extend the Line Compasses from 4 to 8! which done, and that extent apply applied the sime way three times from 9, the movaovable ble Point will first fall upon 18, then from 18 upon upo 36, and at last from 36 upon 72, the weight required.

But if the first two Terms be weights or contents ninas of Solids, and a Line is fought for: Extend the Com-List passes upon the Little Line of Numbers from the first Mea Term to the second; This done; and that extent applied ; thathe same way upon the Great Line of Numbers from the ponth third term will cause the movable Point of the Compasses

l can to fall upon the fourth Term required.

red. If the fide of a Cube weighing 72 pounds be 8 arm inches, how many inches is the fide of a Cube that have weighs 9 pound? Extend the Compasses downwards n the upon the Little Line of Numbers from 72 to 9; which that done, and the same extent applied the same way upon upon the Great Line of Numbers from 8, will cause ach a the movable Point to fall upon 4, the fide required.

PROBL. 8.

Mean Arithmetically Proportional.

This Problem may be performed without the help of the Rule of Proportion: Nevertheless,

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because it conduceth to the resolution of the next hiply fuing Problem, I infert it in this place, and give sum Rule for it: doub

Add half the difference of the given Terms to the Prob fer of them : for, that aggregate is the Arithmetical H

required.

Example, Let 10 and 40 be the Terms give here, if you substract the one out of the other, the difference will be found 30. whose half (15) be added to 10, the leffer Term, their fum (25) is the rithmetical Mean you look for.

PROBL. 9.

here Betwixt two Numbers given, to find blem Mean Musically proportional.

Boetius (Lib. 2. Arith. cap. 38.) hath this Ruk bein it: Differentiam terminorum in minorem terminer ther multiplica, & post junge terminos, & junta o ons qui inde confectus eft , committe illum numerum , qu dim differentis & termino minore productus eft, cujus nia: latitudinem invenerk, addas eam minori termino, 69 25,3 inde colligitur medium terminum pones. Multiply difference of the Terms by the leffer Term, and 10, 1 likewise the same Terms tegether: this done, if Prop divide that Product by the Sum of the Terms, Geom to the Quotient thereof add the leffer Term 116,1 last Sum is the Musical Mean defired.

Or shorter thus:

Divide the Product of the given Term by their Sa for, this done, the Quotient doubled is the mean require be a So the Numbers given being 6 and 12, I fay 12 m that) be

is the

next tiplyed by 6 make 72, which divided by 18 the give Sum of 12 and 6) leaves 4 in the Quotient, whose double (8) is the Mufical Mean you look for. This
the Problem therefore may be performed by the second
and third aforegoing! or yet otherwise thus:

Find the Arithmetical Mean betwixt the Number given and then the Analogy will be thu.

As the Arithmetical Mean found is to the greater. Extreme : fo is the leffer Extreme to the Mu-

fical Mean required.

Example, 10 and 40 being propounded, the Arithmetical Mean betwirt them (by the last Problem) is 25: I fay then, As 25 is to 40, fo is 10 to 16, the Mufical Mean defired: the Term therefore here fought for may be discovered by the fourth Pro-

fina blem aforegoing.

And here (I conceive) it will not be amiss to observe, that by this last Rule, having any two Numbers propounded, you may interject two other Numbers betwixt them! in fuch fort that they four Rule being in feveral relations compared one with another, may contain in them all the three Proportions abovementioned, which kind of Harmony Bo-of eine (lib. 2. cap. ult.) calls Maxima & perfeita sympho-nima nia: So in the Numbers before mentioned 10, 16, ply there shall you find Arithmetical Proportion; if and 40 together, there Harmony, or Musical, if Proportion; if all of them together, there have you ns, Geometrical Proportion discontinued: For as 10 to rm 16, fo 25 to 40. And this is that Harmony which the same Butius (in the same place) affirmeth to have Magnam vim in Musici modulamine temperamentin , & in speculatione naturalium questionum : Great force in the composure of Musick, and in the discovery of the secrets of Nature: And therefore require be also averreth in another place (viz. lib. 1. cap. 2.)

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ding to which Almighty God framed the World: Aco aling to that testified of the Wildom of God (in Wildom of Sol. cap. 11. v. 20.) Then haft ordered Beth things in Measure; and Number; and Weight. The Beth tifts also and Politicians fetch much from these th Proportions for the regular direction of a wells verned Commonwealth, as may be easily collect out of their Writings, and is learnedly proved by din in the last Chapter of his Commonwealth.

PROBL. 10.

Betwixt two Numbers given , to fil being a Mean Geometrically Proportion the oil

Kiend the Compasses upon the Mean Line of No First, bers from one of the Numbers given to the ate Num this done; and the same extent applied upon exten Great Line of Numbers from either of these Numbers 8 to wards the other; the movable Point will fall in the mile upon between them; viz. upon the Point representing the Me Mean

Proportional required. Example; 8 and 32 being propounded, the Ma Proportional between them will be found 16: H if I extend the Compasses upon the Mean Line Numbers, from 8 in the first part thereof to 32 the fecond, and afterwards apply that extent up To the great Line of Numbers from 8 towards 32, movable Point will fall upon 16, the Mean h portional demanded; for as 8 is to 16. fo is 16 32: 10 the Mean betwixt 6.4, and 14. 4, is 9. Gr.

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PROBL.

rdered Betwixt two Numbers given to find two Means Geometrically Proportional. efe the well

d by E Ktend the Compasses upon the Little Line of Numbers given to the other: this done, and that extent applied upon the Great Line of Numbers from either of these Numbers towards tie other; will cause the movable Point to fall first on the Pant representing one of the Mean Numbers required; and being applied again the same way; will at last rest upon 1000 the other Proportional you look for.

Example; Let 8 and 27 be the two Numbers between which two Mean Proportionals are defired. No First, I extend the Compasses upon the Little Line of e at Numbers upwards from 8 to 27: then applying that pon a extent twice upon the Great Line of Numbers from ben 8 towards 27, I find the movable Point to fall first mil upon 12, and then upon 18, which are the two Means you defire to know : for as 8 is to 12, to is

PROBL. 12.

12 to 18, and 18 to 27.

To find the Square-Root of any Number under 1000000.

He Extraction of Roots, which is accounted the hardest Lesson in Arithmetick; is performed by

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he help of this Instrument with greatest ease she So dexterity: for, whereas the Problems before pre ikewil fed, as also those that follow, cannot well be exp dited without the joynt use of the Rule and Com fes together, these of the Extraction of the Sque and Cube Roots may be refolved only by Inspetts without any trouble at all, or and of Compaffes : To e that a man either riding or going in hafte may in mediately read upon the Rule the Root of a Square or Cube Number propounded : which con pendious way of Extraction cannot choose but pro to be of admirable use, especially in questions the concern Military Orders, as shall more plainly pear hereafter. Wherefore to extract the Sona Root proceed thus:

1. When the Figures of the Number given are even, vi Line when the Number consists of two, four, or fix Figures, in forthe same Number in the first part of the Mean Line Diumbers: which done, just at the same Point Shally of likewife find upon the Great Line of Numbers the Sque in t

Root you look fir.

Example, 264196 being propounded, the Square Root thereof will be found 514: for I find the Number 264196 represented in the first part of the Mean Line of Numbers at the Point x, and at the same Point upon the second part of the Great Lin of Numbers I observe 514, the Square-Root n quired.

2. When the Figures of the Number given are odd, vi one, three, or five, Search the Same Number in the Second part of the Mean Line of Numbers: which done, je at the same Point upon the Great Line of Numbers In

you find also the Square-Root demanded.

Example, 144 being propounded, I demand the Square-Root thereof: that Number I find to be me presented in the second part of the Mean Line of Numbers at the Point s, and just there also upon the Great Line of Numbers I discover 12, which is d Comp

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ease the Square-Root of the Number propounded. So re pre likewise is 144 the Square-Root of 20736. be exp

PROBL.

ns beet Hes: To extract the Cube-Root of any Nummay in ber under 100000000. of a

W Hen the Number propounded confists of one; ons th part of the Eistle Line of Numbers : that done, at the fame Point upon the first part of the Great en, vi Line of Numbers, you shall find the Cube-Root you look cres, la for.

Example. Let the Number given be 1728 wherehally of the Cube-Root is required: I find that Number Some in the first part of the Little Line of Numbers at the Point t, and at the same Point upon the Great Line quan of Numbers I also discover 12, the Cube-Root defired: In like manner is 12,52 the Cube-Root of 1950, and 144 the Cube-Root of 2985984.

2. When the Number given confifts of two, five, or eight Figures, fearch it in the Second part of the Little Line of Numbers, and that proceeding as before, you shall have your desire.

Example, If 14348907 were given, the Root thereof would be found 243: for that Number being found in the fecond part of the Little Line of Numbers at the Point w, just at the same Point upon the

Great Line I also find 243, the Cube-Root required. 5. When the Number propounded confists of three, fix, or nine Figures, look for it in the third part of the Little Line of Numbers : for Solkewise at the Same Point upon the Great Line will appear the Root required.

Sa

So the Number 159220088 being found in a first part of the Little Line of Numbers at the Pot, his Cube-Root is there likewise found upone Great Line of Numbers to be 542: And the Cub Root of 159220. is found to be 54.

2, &e.

The order of finding out the Cube-Numbers upon the feveral parts of the Line may be fitly expressed by this Figure

1	2	3
1	2	3
4	5	6
7	8	9

CAP. V.

The Use of the Rule of Proportion on in Geometry, viz.

In the Dimension,

1. Of Plain Triangles.

PROBL. 1.

The three Angles and one Side being known, to find the other two Sides.

To refolve this Problem this is the Analogy.

As the Sine of the Angle opposed to the fide

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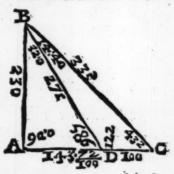
known is to the parts of the same side: so is the Angle opposed to one of the sides unknown, to the parts which measure that side: And therefore

Extend the Compasses across from the Sine of the Angle opposed to the side known; to the same side; found upon the Moan Line of Numbers: then applying that extent the same way from the Sine of the Angle opposed to one of the sides required; the movable Point will fall upon

the parts which measure that required side.

Example In the Triangle C, B, D, let the Angle C be 43 degr. 20 min. the l Angle D 122 d and by confequent the Angle B (being the Complement of the two other Angles to 180 d. or two right Angles) 14 degr. 40 min. and let the fide D, C, being 100 paces reprefent the distance between the two stations D and C: I demand then the distance between C and C: Extend the Compasses across from 14 degr. 40 mi. upon the Line of Sines to the middle of the Mean.

Eine of Numbers representing 100, then that extent being applied the same way from 122 d. upon the Line of Sines or (which is all one) from 58 degr. (for by the Rules of Trigonometry the Sine of an obtack Angle and



that of his Complement to 180 is one and the fame Line) will cause the movable Point to fall upon 135, and so many paces is the distance required: In like manner, the extent being applied the same way from 43 d. 20 m. upon the Line of Sines, the movable C 5

Point will fall upon 271, the parts of the fide D, B. kno Or otherwise, by changing the Terms of the A. sed

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nalogie, thus:

Extend the Compasses outright upon the Line of appl Sines from 14 d. 40 m. to 58 d. then applying that Ang extent the same way upon the Line of Number from from 100, the moveable Point will rest upon 335, move the distance required: so likewise the Compasses quire being extended outright upon the Line of Sines from 14 d.40 m.to 43 d. 20 m. and that extent ap being plied the fame way upon the Line of Numbers from 100, the moveable Point willfall upon 271, the part foun of the fide D, B.

And here observe, that not only this present Pro. d. o blem, but also all those that follow (which concern Line the refolution of Triangles) may be refolved two manner of wayes, viz. by working either outright or across, except some few, which we intend to mark in their proper places. Remember likewife what hath been before touched in the second Chapter aforegoing, viz. that the Mean Line of Number ir the only Line to be used with these of Sines and

Tangents, and no other.

P K OB 45 2.

By the Knowledge of two Sides and an Angle opposed to one of them, to find the other two Angles and the third Side.

His is the Inverse of the last Problem: for, as the fide opposed to the given Angle is, to the Sine of the same Angle; so is the other fide known D, B, known, to the Sine of the Angle thereunto oppo-

ne A fed : And therefore

Extend the Compasses across from the parts of the side ine of aposed to the Angle known, unto the Sine of the Same that Angle: then that extent being applyed the same way mben from the parts of the other known fide, will cause the 335, movable Point to fall upon the Sine of the Angle re-

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So in the forefaid Triangle C, B, D, the fide C, B, Sines t ap being 335, the Angle D. (opposed thereunto) 122 d. from o m. and the fide D, C, 100, the Angle B will be para found 14 d. 40 m. For if you extend the Compaffes across from:335 upon the Line of Numbers, to 122 Pro. d.q m. (or rather to 58 d. o m. as aforefaid) upon the ncern Line of Sines, and after apply that extent the same two way from 100 upon the Line of Numbers, the moveright able Point will reft upon 14 d. 40 m. the measure of the Angle B required. mark

Now having the knowledge of two Angles, the what other may be eafily difcovered, being the Compleapter ment of those two to 180, as aforefaid: And the nben Angles being known, the other fide may be also found

by the Problem aforegoing.

PROBL. 3.

By the Knowledge of two Sides and the Angle included, to find the other two Angles and the third Side.

Fithe Angle included be a right Angle, this is the Proportion : as the greater fide is to the leffer ; fo is the Tangent of 45 d. o m. to the Tangent of the leffer Angle. And therefore.

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Extend the Compasses upon the Line of Numbers downwards from the greater to the less side: then if you apply that extent upon the Line of Tangents the same way from 45 d. the movable Print will fall upon the Tangent of

the leffer Angle.

Example; In the Rectangle Triangle, \mathcal{A}_i , \mathcal{B}_i , \mathcal{D}_i of the Diagram aforegoing, the fide \mathcal{A}_i , \mathcal{B}_i being 236, and the fide \mathcal{A} . \mathcal{D} , 143. 72; the Angle \mathcal{B} will be found 32 \mathcal{d} . o \mathcal{m} . For, if you extend the Compaffer downwards upon the Line of Numbers from 230 to 143. 72, that extent being applied the fame way from 45 \mathcal{d} . at the top of the Line of Tangents, will cause the movable Point to fall upon 32 \mathcal{d} . o \mathcal{m} . viz. the measure of the Angle \mathcal{B}_i whose Complement 36 \mathcal{d} . o \mathcal{m} . is the measure of the Angle \mathcal{D} : And now the three Angles being thus discovered, the third side may also be known by the first Problem of this Chapter.

But if the included Angle be Oblique, viz. either obtuse or acute, then this is the Analogy: As the Sum of the sides known is, to the difference of the sime sides: so is the Tangent of the half Sum of the Angles unknown, to the Tangent of half their

difference: And therefore

Extend the Compasses upon the Line of Numbers dovewards and upright from the Sum of the given sides, unto their difference: then applying that extent upon the Line of Tangents from the half Sum of the Angles unknown; the movable Point will fall upon the Tangent of half their difference; which being added unto the said half Sum; make up the greater, but being deducted from it discovers the lesser of the Angles you look for.

An Example of this Problem, when the moity of

the Angles opposed exceeds not 45 d.

In the Triangle B_i C_i D_i the fide D, B, being 271, the fide D_i C_i 100, and the Angle D_i 122 d the Angle B will be found 14 d. 40 m. and the Angle C_i 43 d. 20 m. For, if you extend the Compaftes upon the

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Mean Line of Numbers downwards from 371 (the Sum of the fides known) to 171 (their difference) that extent being applied the fame way upon the Line of Tangents from 29 d. (half the Sum of the Angles B and C, the movable Point will fall upon 14 d. 20 m. which being added to 29 d. amounts to out of them, the remainder is 14 d. 40 m. For the Angle B.

Two other Examples of this Problem, when the

moity of the Angles opposed exceeds 45 d.

r. In the tame Triangle C; B; D; the fide C; B; being \$35, the fide C; D; 100; and the Angle C; 43 d. 20 m. the Angle D will be 122 d. and the Angle B 14 d. 40 m. For; if you extend the Compaffes upon the Line of Numbers downwards from 435 (the Sum of the fides known) to 235 (their difference) that extent being applied upon the Line of Tangents backwards (viz. upwards) from 68 d. 20 m. (the half Sum of the Angles D and B required) the movable Point will fall upon 53 d. 40 m. which being added to 68 d. 20 m. their Sum is 122 d. 0 m. viz. the measure of the Angle D; and being deducted out of the same 68 d. 20 m. the remainder is 14 d. 40 m. the Angle B.

2. The fide B_j C, being 335, the fide B_j D; 271; and the Angle B 14 d. 40 m. I demand the Angles: D and C: the Sum of the fides B_j C; and B_j D; is 606, their difference is 64, and the Angle C being 14 d. 40 m. the Sum of the Angles opposed and unknown is 165 d. 20 m. and half that is 82 d. 40 m. Now to fatisfie this demand; I extend the Compassies upon the Line of Numbers downwards from 606 to 64: then, because if I apply that extent upon the Line of Tangents backwards (viz. upwards, as before) from 82 d. 40 m. the movable Point will fall as far beyond the top of that Line, ar the Term I laok for is situate on this side, I apply that extent down-

downwards from 45 d. o m. caufing the movable from Point also to fall upon the same Line: that done, able and the movable Point remaining there fixed, I close Gubith the Compasses till the other Point may rest upon in the 82 d. 40 m. And having the Compasses so extendded, if applying that extent downwards, I fet one of the Points at 45 d. the other will reach to 39 d.20 m. which being added to 82 d. 40 m. amounts to 122 d. viz. the Angle D: but being deducted out of 824 40 m. the remainder is 43 d. 20 m. wiz. the measure of the Angle C.

And in these three Cases having discovered the three Angles, the other fide may be likewise found by the first Problem of this Chapter: Observe also that these two last Examples will not admit of Croswork: and therefore are Exceptions to the General Rule delivered in the end of the same Problem.

PROBL. 4.

The three Sides being known, to find the Perpendicular, and the three Angles.

He greatest side being affigned for the Base, upon which the Perpendicular shall be supposed to fall, find the Sum and the difference of the other fides: that done, the Proportion will be this: As the Base is to the Sum of the other sides, so is the difference of the other fides to a fourth Number which being deducted out of the Base, the Perpendisular will fall in the middle of that which remains: Andth erefore

Extend the Compasses upon the Line of Numbers from be parts of the Base unto the Sum of the parts of the other Ade: the done, and that extent applied the same way F0778

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ovable from the difference of the other sides, will case the movedone, able Point to fall upon a fourth Number, which if you I close substract out of the intire Base, the Perpendicular will fall upon in the middle of the remainder.



Example, in the Triangle E, F, G, the fide E, F, being 13, the fide F, G, 11, and the Base E, G, 20, I domand the Point of the Base, where the Perpendicular ought to fall, and then the three Angles of the fame Triangle: The Sum of the fides is 24, and their difference is 2: I extend therefore the Compasses upon the Line of Numbers from 20 to 24: that done, in this Example (because by the third Corollary of the fust Problem of the third Chapter, the Numbers 20 and 2 are both represented at the same Point) you may observe (without any farther search) the movable Point to discover the parts of the Segment E. C. viz. 2. 4, which being deducted out of 20, there remains 17, 6, whose half is 8, 8, which are the parts of the Base comprehended betwixt Cand A. or. betwixt A and G: I conclude therefore that A is the Point of the Bale where the Perpendicular ought to fall. Now in the Triangle A.F.G, the fides A, G, and G, F, being known, as also the Angle F, A, G, (which is a right Angle by the 10. Def. of the 1. El. of Eucl.) the Angles G, and F, as also the Perpendicular F, A, may be found by the I and 2 Probl. of this Chapter. In like manner in the Triangle E, F, A, the fides E.A. and E, F, as also the Angle E, A, F, being known. the Angles E, and F, may be found by the 2, Probl.

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of this Chapter. And laftly, if you add the Angle ber E, F, A, and A, F, G, together, their aggregate will fixed make up the Angle E; F; G : And fo by the know ledge of the three fides have you all the parts of the Copt Triangle throughly refolved.

PROBL V.

The three Sides being known, to find bers the Area, or Superficial Content.

Rom the half Sum of the three fines deduct each fide, to the end you may discover the difference betwixt the fiid half Sum and each fide : the done, the Proportions will be as followeth ::

1. As I is to the first difference; fo is the second dif-

ference to a fourth Number.

2. As I is to that fourth Number, fo is the third difference to a fixth Number.

3. As I is to that fixth Number, fo is the half Sum to an eighth Number, whose Square-Root is the Area re

quired.

Example; The three fides of the forefaid Triangle E, F; G, being 20, 13, and 11, their Sum is 44, half thereof is 22, and the differences betwixt each fide and that half are 2, 9, and 11: The operation being thus prepared (because the Number required is Square-Root) I extend the Compasses upon the Mean Line of Numbers upwards from 1-to 2: then that extent being applied the same way from 9 (in the first part of that Line) the movable Point will fall upon 18 the fourth Number: this done, and the movable Point remaining there fixed, close the Compaffes till the other Point fall again upon 13: for that extent being applied from 1-1, will cause

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Ange the movable Point to fall upon 198, the fixth Number: again, the movable Point remaining there the w fixed, as before, open the Compaffes till the other know point may yet again fall upon 1, and may interof the cept between the Legs the distance betwirt 1, and 198: for that done, if you apply the fame extent (in the first part of the sime Line) from 22, the movable Point will fall upon 4356, whose Square-Root (by the 12. Probl. of the laft Chapter) will appear at the same Point upon the Great Line of Numbers to be 66, which is also the Area required.

2. Of Spherical Rectangle Triangles.

PROBL. 6.

The two Sides being given, to find the Base.

IN Spherical Restangle Triangles, the fide which I subtends the right Angle, is called the Base, which to find by the knowledge of the other fides, use this Analogy following:

As the Radius or Sine of 90 d. is to the Sine of the the Complement (otherwise called the Co-sine) of one of the fides: so is the Co-fine of the other fide to the Co-fine of the Bafe: And therefore

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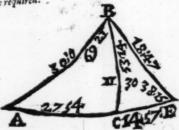
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Extend the Compasses downwards uppon the Line Sines from 90 d. to the Co-Sine of one of the fides: the exceed applying that extent the same way from the Co-Sine of the of Sine other fide, the movable Point will rest upon the Co-fine of require the Bafe required.



Example. In the Triangle A, B, C, the fide A, being 27 d. 54 m, and the fide C, B, 11 d, 30 m.th Base B, A, will be found 30 d. o m. for if you exten the Compaffes downwards from 90 d. to 62 d. 6 m (the Complement of 27 d. 54 m. and after appl that extent the same way from 78 d. 30 m. (th Complement of 11 d. 30 m.) the movable Point wil fall upon 60 d. being the Complement of 30 d. the Bafe required.

PROBL.

The two Sides being known, to find en ther of the Oblique Angles.

A S the Sine of the fide next the Angle required at is to the Radius: so is the Tangent of the op posite side to the Tangent of the same Angle, al And therefore

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Lined 1. When the fide opposed to the Angle required es: the exceeds not 45 d. Extend the Compasses upon the Line ne of the Sines from the Sine of the side adjacent to the Angle o-fine, required, to 90 d. then that extent being applied the same way upon the Line of Tangents, from the Tangent of the side opposed to the required Angle, the movable Point will fall upon the Tangent of the same required Angle.

1. Example, In the faid Triangle A,B,C, the fide A.C. being 27 d. 54 m. and the fide C, B, 11 d. 30 m. Idemand the Angle A. Extend the Compasses upon the Line of Sines from 27 d. 54 m. to 90 d. then that extent being applied the same way upon the Line of Tangents from II d. 30 no. the movable Point will

rest upon 23 d. 30 m. the Angle A required.

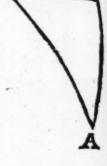
Or otherwise thus: Extend the Compasses across from 27 d. 54 m. upon the Line of Sines to 11 d.; 30 m. upon the Line of Tangents: then applying that extent the same way from 90 d. upon the Line of e 1.0 m. the Sines, the movable Point will fall upon the Line of Tangents at a Point representing 23 d. 30 m. as bed. 6 a fore And note s that in this case the Term required will always fall out to be less then 45 d.

2 Example, To know the Angle B: Extend the Compasses Aupon the Line of Sines from 11 d. 30 m. to go d. then (because that extent being applied d. the upon the Line of Tangents the sime way from 27 d. 54 m will cause the movable Point to fall as far beyond the top of that Line, as the Term required is fituate, on this fide) apply the same extent backwards upon the Line of Tangents from 45 d. caufing the movable Point to fall alto upon the fame Line: for, that done, and the movable Point remaining fixed at the Point where it falls, close the Compasses. till the other Point may fall upon 27 d: 54 m, And at last that extent being applied outright upon the e of Line of Tangents from 45 degr. will cause the moveagle, able Point to rest upon 69 d. 21 m. the Angle B required. Or otherwise: Extend the Compasses a-

cross from 11 d. 30 m. upon the Line of Sines to 2 Ca d. 54 m. upon the Line of Tangents: then if you apply that extent backwards from 90 d. upon the Line of Sines, the movable Point will fall upon the Line of Tangents at a Point representing 69 d. 21 m. as before. And here the required Angle is alway greater than 45 d.

2. When the fide opposed to the Angle require exceeds 45 d. Extend the Comp. fes upon the Line Sines from the Sine of the fide adjucent to the Anglen quired, to 90 d. That done, if you apply that exiet backwards upon the Line of Tangents from the Tangent the side opposed to the faid required Angle, the moval Point will fall upon the Tangent of the same Angle.

Example, In the Diagram annexed, the fide A, C, being 61 d. 53 m. and B, C, 54 d. 28 m. the Angle A will be found 57 d. 47 m. For, the Compaffes being extended upon the Line of Sines from 61 d. 53 m. to 90 d. and that extent applied backwards upon the Line of Tangents from 54 d. 28 m. the movable Point will fall upon 57 d. 47 m. the Angle A required. And here observe I. that in



Examples of this kind you cannot work acros: 1 The Angle here found is alwayes greater that 45 d.

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PROBL. 8.

The Base and one of the Oblique Angles being given, to find the other Oblique Angle.

A S the Radius to the Co-fine of the Base; so is the Tangent of the Angle known to the Co-tangent of the Angle required: And therefore 1. When the Angle given exceeds not 45 d. Ex-

tend the Compasses upon the Line of Sines from 90 d. to the Co-sine of the Base: then if you apply that extent the same way upon the Line of Tangents from the Tangent of the Angle given; the movable Point will fall upon the

Cotangent of the required Angle.

Example, In the Diagram of the fixth Probl. the Base A, B, being 30 d. and the Angle A 23 d. 30 m. the Angle B will be found 69 d. 21 m. For, if the Compasses be extended upon the Line of Sines from 90 d. to 60 d. (the Complement of the Base) and that extent applied the same way upon the Line of Tangents from 23 d. 30 m. the movable Point will rest upon 20 d. 39 m. whose Complement (found alfo at the fime Point) is 69 d. 21. m. the Angle B required. Or otherwise by cross-work, thus: Extend the Compasses from 90 d. upon the Line of Sines to 23 d. 30 m. upon the Line of Tangents: then that extent being applied the same way from 60 d. upon the Line of Sines, the movable Point will fall upon the Line of Tangents at the Point representing 20 d. 39 m. as before. And here observe, that (in this case) the Angle you look for is alwayes less than 45 d.

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2. When the Angle given is greater than 40 Extend the Compasses upon the Line of Sines from 90 to the Co-sine if the Base: this done, if you apply to extent upon the Line of Tangents backwards from Tangent of the Angle given, the movable Point will The upon the Co-tangent of the Angle required.

I. Example, In the Diagram of the fixth Probl A, being 30 d. and the Angle B 69 d. 21 m. Angle A will be found 23 d. 30 m. For if the Co paffes be extended upon the Line of Sines from d. to 60 d. and that extent applied backwards up the Line of Tangents from 69 d. 21 m, the move Point will fall upon 66 d. 30 m. the Complement 23 d. 30 m. the Angle A required. And in this d you cannot use cross-work, and the last Term for upon the Rule is alwayes greater than 45 d. but de Comp

Term required less.

2. Example, In the Diagram produced in the Jame Probl. B, A. being 74 d. 6 m. and the Angle B 66 the 30 m. the Angle A will be found 57 d. 47 m. For, the 1 you extend the Compasses upon the Line of Sin from 90 d. to 15 d. 54 m. and then (because that of ing) tent being applied backwards, as before, upon you Line of Tangents from 66 d. 30 m. will cause the 293. movable Point to fall beyond that Line) if you my leffe ceed as you were directed in the second Example the faid last Probl. at last the movable Point wil passe rest upon 32 d. 13 m. the Complement of the And the A required. Or otherwise by cross-work: Exten Same the Compasses from 90 d. upon the Line of Sines the 66 d. 30 m. upon the Line of Tangents: This dom the if you apply that extent backwards from 15 d. 54s upon the Line of Sines, the movable Point will a upon the Line of Tangents at the Point represental 47 32 d. 13 m. as before. And (in this cafe) the let in t Term found upon the Rule is alwayes less than 454, four but the Term required greater.

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PROBL. 9.

The Base and one of the Oblique Angles being known, to find the Side adjacent to the same Angle.

norm AS the Radius is to the Co-fine uf the Angle Tangent of the fide required: And therefore,

four t. When the Base is less than 45 d. Extend the out the Compasses upon the Line of Sines from 90 d. to the Cofine of the Angle known: then applying that extent the he fame way upon the Line of Tangents from the Tangent of 3 66 the Base, the movable Point will fall upon the Tangent of For the side required.

Sim So in the Diagram of the fixt Problem, B, A, being 30 d. and A 23 d. 30 m. the fide A, C, (whether onthyou work outright or across) will be found 27 d. 54 fe m. And in this case the Term required is alwayes

u po leffer than 45 d.

2. When the Base exceeds 45 d. Extend the comtwi passes upon the Line of Sines from 90 d. to the Co-sine of And the Angle known, as before: that done, if you apply the sten Same extent upon the Line of Tangents backwards from nest the Tangent of the Base, the movable Point will rest upon don the Tangent of the side required.

548 So in the Diagram produced in the seventh Pro-In blem, B, A, being 74 d.6 m. and the Angle A 57 d. nin 47 m. the fide A. C. will be found 61 d. 53 m. And in this case you cannot work across, and the side to be

454 found will be always greater than 45 d.

Now if in applying the extent of the Compaffes from the Tangent of the Base, the movable Point talls

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2. When the Angle given is greater than 454 Extend the Compasses upon the Line of Sincs from 90d to the Co-sine of the Base : this done, if you apply the extent upon the Line of Tangents backwards from the Tangent of the Angle given, the movable Point will fa upon the Co-tangent of the Angle required.

1. Example, In the Diagram of the fixth Proble A, being 30 d. and the Angle B 69 d. 21 m.th Angle A will be found 23 d. 30 m. For if the Com paffes be extended upon the Line of Sines from w d. to 60 d. and that extent applied backwards upon the Line of Tangents from 69 d. 21 m, the movable Point will fall upon 66 d. 30 m. the Complementa 23 d. 30 m. the Angle A required. And in this cal you cannot use cross-work, and the last Term found upon the Rule is alwayes greater than 45 d. but the

Term required less.

2. Example, In the Diagram produced in the Probl. B, A. being 74 d. 6 m. and the Angle B 661 30 m. the Angle A will be found 57 d. 47 m. For i you extend the Compasses upon the Line of Sine from 90 d. to 15 d. 54 m. and then (because that or tent being applied backwards, as before, upon the Line of Tangents from 66 d. 30 m. will cause the movable Point to fall beyond that Line) if you proceed as you were directed in the second Examples the faid last Probl. at last the movable Point wil rest upon 32 d. 13 m. the Complement of the Ang A required. Or otherwise by cross-work: Exten the Compasses from 90 d. upon the Line of Sines ,66 d. 30 m. upon the Line of Tangents: This don if you apply that extent backwards from 15 d. 54 m upon the Line of Sines, the movable Point will re upon the Line of Tangents at the Point representing 32 d. 13 m. as before. And (in this case) the la Term found upon the Rule is alwayes less than 454 . fou but the Term required greater.

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PROBL. 9.

The Base and one of the Oblique Angles being known, to find the Side adjacent to the same Angle.

As the Radius is to the Co-fine uf the Angle known; so is the Tangent of the Base to the Tangent of the fide required: And therefore,

t. When the Base is less than 45 d. Extend the compasses upon the Line of Sines from 90 d. to the Co-fine of the Angle known: then applying that extent the same way upon the Line of Tangents from the Tangent of the Base, the movable Point will fall upon the Tangent of the side required.

So in the Diagram of the fixt Problem, B, A, being 30 d. and A 23 d. 30 m. the fide A, C, (whether you work outright or across) will be found 27 d. 54 m. And in this case the Term required is alwayes

leffer than 45 d.

2. When the Base exceeds 45 d. Extend the compasses upon the Line of Sines from 90 d. to the Co-sine of the Angle known, as before: that done, if you apply the same extent upon the Line of Tangents backwards from the Tangent of the Base, the movable! Point will rest upon the Tangent of the side required.

So in the *Diagram* produced in the feventh Problem, B, A, being 74 d.6 m. and the Angle A 57 d.47 m. the fide A. C. will be found 61 d.53 m. And in this case you cannot work acros, and the fide to be

. found will be always greater than 45 d.

Now if in applying the extent of the Compaffes from the Tangent of the Base, the movable Point falls

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falls beyond the Line, work as you were befored rected in the second Example of the seventh Imblem aforegoing, and so shall you also in that a discover the side you look for, which will then a wayes happen to be less than 45 d.

PROBL. 10.

The Base and one of the Oblique Angle being known, to find the Side opposed to the same Angle.

A S the Radius is to the Sine of the Bafe, so is in Sine of the Angle known to the Sine of the Side required: And therefore

Extend the Compasses upon the Line of Sines from a cl. to the Sine of the Base: Fer, that extent being appled the same way from the Sine of the given Angle me cause the movable Point to fall upon the Sine of the surgained.

Example, In the Diagram of the fixth Problem to know the fide B, C, extend the Compaffest on the Line of Sines from 90 d. to 30 d. then if yo apply that extent the same way from 23 d. 30 m the movable Point will fall upon 11 d. 30 m. the same required.

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PROBL.

One of the Sides and the Oblique Angle next unto it being known, to find the Base.

ngle A S the Co-fine of the Angle known is to the Tangent of the Bale: And therefore. to the Tangens of the Base: And therefore,

1. When the fide given exceeds not 45 d. Extend the Compasses upon the Line of Sines from the Co-sine of the Angle given, unto 90 d. This done, and that extent applied the Same way upon the Line of Tangents from of th the Tangent of the side given , will cause the movable From Point to fall upon the Tangent of the Base. So in the Diagram of the fixth Probl. the Angle A being 23 magram of the fixth Probl. the Angle A being 23 d. 30 m. and the fide A, C, 27 d. 54 m. the Base B, A, will be found 30 d. o m. But here, if the movethe fi able Point chance to fall beyond the Line, proceed as blem of the a Double of the a of the 7. Probl. And in that case the Term required ficsus will alwayes prove greater than 45 d.

if yo 2. When the given fide exceeds 45 d. Extend the 30 n Compasses upon the Line of Sines from the Co-fine of the Angle given, unto 90 d. then, if you apply that extent upon the Line of Tangents backwards from the Tangent of the side given, the movable Point will fall upon the Tangent of the Base. So in the Diagram of the teventh Probl. the Angle A being 57 d. 47 m. and the fide A, C, 60 d. 53 m. the Base B, A, will be found 74 d. 6 m. And here the Term fought for is always great-

Iller than 45 d.

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PROBL. 12.

One of the Sides and the Oblique A gle next unto it, being known, to fa on the other Side.

As the Radius is to the Sine of the fide gire fo is the Tangent of the Angle known to Tangent of the fide required: And therein

1. When the Angle given exceeds not 45 d. 1 tend the Compasses upon the Line of Sines from 90 unto the Sine of the given side: this done, and that tent applied the same way upon the Line of Tang d. te from the Tangent of the Angle known; will cause tent movable Point to fall upon the Tangent of the fide remi give So in the Diagram of the fixth Probl. A, C; being red. d. 54 m. and the Angle A, 23 d. 30 m. the fide I beir will be found II d. 30 m. And in Examples of Ang kind cross-work may be used, and the Term for for is always less than 45 d.

2. When the Angle given exceeds 45 d. En the Compasses as before: which done, if you apply that tent upon the Line of Tangents backwards from the gent of the given Angle, the movable Point will fall On on the Tangent of the side required. So in the Dian of the seventh Probl. B; C, being 54 d. 28 m. and Angle B, 66 d. 30 m. the fide A, C. will be found d. 53 m. This Example and the like cannot be formed by cross-work; and here the Term fu is alwayes greater than 45 d. But if in applying Compasses backwards the movable Point character A to fall beyond the Line, work as you were be directed in the second Example of the seventh

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PROBL. 13.

One of the Sides and the Oblique Angle next unto it being known, to find the other Oblique Angle.

S the Radius to the Co-fine of the given Side, om 50 fo is the Sine of the Angle known, to the Cofine of the Angle required: And therefore

Extend the Compasses upon the Line of Sines from 90 Tange l cause d. to the Co-fine of the fide given : this done, that extent being applied the same way from the Sine of the given Angle; will reach to the Co-fine of the Angle requibeing red. So in the Diagram of the fixth Problem A; C; fide # being 27 d. 54 m. and the Angle A 23 d. 30 m. the Angle B will be found 69 d, 21 m.

PROBL.

n the l outfall One of the Sides and the Angle opposed Diag unto it being known, to find the and Base. found t be

A S the Sine of the Angle given is to the Sine of the fide given: so is the Radius to the Sine of the Base: And therefore

Extend the Compasses from the Sine of the Angle given

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to the Sine of the given side: then if you apply the extent sion 90 d. the motable Point will fall upon the Sine of the Base. So in the Diagram of the fixth Problem, 4, being 23 d. 30 m. and the side B, C, 114 30 m. the Base B, A, will be found 30 d. 0 m.

PROBL. 15.

One of the Sides and the Angle oppofed unto it being known, to find the other Oblique Angle.

As the Co-fine of the fide given is to the Co-fine of the Angle given; so is the Radius to the Sine of the Angle required: And therefore, Extend the Compasses from the Co-fine of the given the Co-fine of the given the Co-fine of the given that come

to the Co-sine of the given Angle: this done, that each being applied the same way from the Radius, will call the movable Point to fall upon the Sine of the Angles quired. So in the Diagram of the fixth Problet the fide A, C, being 27 d. 54 m. and the Angle B, 6 d. 21 m. the Angle A, will be found 23 d. 30 m.

PROBL. 16.

One of the Sides and the Angle opposed unto it being known, to find the other Side.

AS the Tangent of the Angle given is to a Tangent of the fide given; to is the Radim

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the Sine of the fide required: And therefore,

1. When neither the Angle nor fide given exceeds 45 d. Extend the Compasses downwards upon the Line of Tangents from the Tangent of the Angle given, to the Tangent of the side given: this done, the extent being applied the same way upon the Line of Sines from 90 d. wilreach to the Sine of the side required.

So in the Diagram of the fixth Problem, the Argle A being 23 d. 30 m. and the fide B, C, 11 d. 30

m. the fide A, C, will be found 27 d.54 m.

2. When the Angle and the fide given do each of them exceed 45 d. Extend the Compaffes upon the Line of Tangents upwards from the Tangent of the Angle given to the Tangent of the fide given, then if you apply that extent backwards upon the Line of Sines from 90 d the mroable Point will fall upon the Sine of the fide required.

So in the Diagram of the feventh Problem, the Angle B being 66 d. 30 m. and the fide A, C, 61 d.

53 m. the fide B, C, will be found 54 d. 28 m.

3. When the Angle is greater, and the fide less then 45 d. Extend the Compasses upon the Line of Tangents downwards from 45 d. to the Tangent of the Angle given, then if that extent be applied the same way from the Tangent of the given side, the movable Point will fall upon a Point, Tshich upon the Line of Sines represents to a

Sine of the side required.

So in the Diagram of the fixth Problem, the Angle B being 69 d. 21 m. and the fide A, C, 27 d. 54 m. the fide B, C, will be found 11 d. 30 m. And here observe, that Examples of this kind may likewise be performed by cross-work, the extent of the Compasses being applied backwards: For, having extended the Compasses across from 69 d. 21 m. upon the Line of Tangents to 90 d. upon the Line of Sines, if you apply that extent backwards and across from 27 d. 54 m. upon the Line of Tangents, the movable Point will fall upon the Sine of 11 d. 30 m. the fide required.

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PROBL

PROBL. 17.

One of the Sides and the Base beingly the known, to find the Angle opposed the same Side.

S the Sine of the Base is to the Radius; so i the Sine of the fide known to the Sine of the Bale B Angle required: And therefore,

If you extend the Compasses from the Sine of the Bu beit in unto 90 d. that extent being applied the same way, mi reach from the Sine of the great side unto the Sine of the Angle required. So in the Diagram of the fixth Pro fixteen blem, B, A, being 30 d. and the fide B, C; 11 d. 30 m. the Angle A will be found 23 d. 30 m.

PROBL. 18.

One of the Sides and the Base being known, to find the Oblique Angle adjacent unto that Side.

S the Tangent of the Base is to the Tangent of A the given fide; so is the Radius to the Co-fine of the Angle required: And therefore,

1. When neither the Base nor the side given exceeds 45 d. the extent from the Tangent of the Base ti the Tangent of the side given, being applied the same way, will reach from 90 d. to the Cosme of the Anglere quired.

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So in the Diagram of the fixth Problem, the Bate A, being 30 d. and the fide A, C, 27 d. 54 m. e Angle A will be found 23 d. 30 m. And in his case cross-work may also be used, if you aply the Compasses the same way they were extended.

2. When the Base and the fide given do cach of them exceed 45 d. The extent upwards from the Tangent of the Base to the Tangent of the given side being applied backwards, will reach from 90 d. to the Ci-fine of

the Angle required.

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fo i So in the Diagram of the seventh Problem, the of the Bale B, A, being 74 d. 6 m. and the fide A, C, 61 d. 13 m. the Angle A will be found 57 d. 47 m. How-

3. When the Base is greater, and the side less than If it 45 d. Work as you were taught in the third Rule of the

h Pro fixteenth Problem aforegoing.

PROBL. 19.

One of the Sides and the Base being known, to find the other Side.

S the Co-fine of the fide given is to the Radius; fo is the Co-fine of the Bafe to the Co-fine of the fide required: And therefore,

The extent from the Co-fine of the fide given to god. being applied the same way, will reach from the Co-fine of

the Base, to the Co-fine of the side required.

So in the Diagram of the fixth Problem the Bafe B, A, being 30 d. and the fide A, C, 27 d. 54 m. the fide B, C, will be found 11 d. 30 m.

> D 4 PROBL.

PROBL. 20:

The two Oblique Angles being know to find the Bafe.

S the Tangent of one of the Angles is to A Cotangent of the other Angle; io is: Kadiss to the Co-fine of the Bate : And the 3. fore,

1. When one of the Angles given, and the Co plement of the other are each of them less thand d. The extent from the Tangent of the Angle left ite 45 d. unto the Co-tangent of the other, will reach for 90 d. to the Co-fine of the Bafe. So in the Diagrams the fixth Problem the Angle A being 23 d. 301 and the Angle B 69 d. 21 m. the Base B, A, will found 30 d. And here crofs-work may likewife utcd.

2. When one of the Angles is greater, and the Complement of the other less than 45 d. Proceed you have been laught in the third Rule if the 16. In blem of regung.

PROBL. 21.

The two Oblique Angles being known to find either of the Sides.

S the Sine of one of the Angles is to the Co A sthe sine of the other Angle: so is the Radius in the Cofine of the fide opposite to the Angk whose Co-fine was taken: And therefore,

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The extent from the Sine of one of the Angles given, to the Co-fine of the other, being applied the fame way, will reach from 90 d. to the Co-fine of the fide apposed to the Angle, whose Co-fine was taken.

So in the Diagram of the fixth Problem, the Angle A being 23 d. 30 m. and the Angle B 69 d. 21 m

the fide A, C, will be found 27 d. 54 m.

3. Of Spherical Oblique Angle Triangles.

PROBL.

Two Angles and a Side opposed to one of them being known, to find the Side opposed to the other.

S the Sine of the Angle subtended by the side known is to the Sine of the same fide; so is the Sine of the Angle subtended by the fide required, to the Sine of that fide: And therefore,

The extent from the Sine of the Angle opposed to the side known, unto the Sine of the Same side, being applied the same way from the Sine of the Angle oppised to the side required, will reach to the Sine of the side so required.

So in the Diagram of the fixth Problem, the Angle E, being 38 d. 15 m. the fide B, A, 30 d. and the Angle A 23 d. 30 m. the fide B, F, will be found 18 d. 47 77.

> PROB. D 5.

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PROBL. 23.

Two Sides and the Angle opposed to In a one of them being known, to find the Angle opposed to the other Side.

A 5 the Sine of the fide subtending the Angle known is to the Sine of the same Angle; is the Sine of the fide subtending the Angle required, to the Sine of that Angle: And therefore,

The extent from the Sine of the side subtending the Angle known, to the Sine of the Same Angle, being ap plied the same way, will reach from the Sine of the fide Subtending the Angle required, to the Sine of that Angle

So in the Diagram of the fixth Problem, B, A. being 30 d. the Angle E 38 d. 15 m. and the fide & E, 18 d. 47 m. the Angle A will be found 23 d. 30 m.

The studious Reader bath by this time (I presume) for well acquainted himself with the turnings and winding of this Instrument, that in the resolution of most of the ansuing Problems, it will (I concerve) be only necessary to produce the bare Analogy, without annexing either Rule er Example as heretefore, and to refer the proper application thereof, to his farther industry and discretion.

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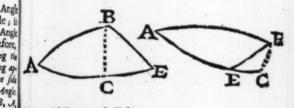
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PROBL. 24.

ed to In any of the Triangles annexed, the Sides A, B, and A, E, together with the Angle A, being known, to find the Side B, E,



IN an Oblique Angle Triangle, when the Terms propounded are two fides and one Angle, or two Angles and one fide, and yet the Term required undiscoverable by the two last premised Problems, you are to con-



vert fuch a Triangle into two Rectangle Triangles, by supposing a Perpendicular to be let fall from any one of the Angles upon his opposite side, in such fort that two of the Terms propounded may in one of those Rectangle Triangles still remain given and intire; for by this means all the other parts of fuch a Triangle thus converted, may be readily discovered by the Analogies of Rectangle Triangles: And the Pergendicular thus imagined, will fall within the Triangle, when the Angles adjacent to the fide upon

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upon which it falls, are of one and the fame kin that is, both acute, or both obtufe; but othern without the Triangle, when shofe Angles are of fering kinds, viz. the one acute and the other obt as plainly appears by the Triangles annexed, in whi (having the fides A, B, and A, E. as also the Am A propounded) to find the fide B, E, use these A ligies following:

1. As the Radius is to the Co-fine of A; fo is

Tangent of A, B, to the Tangent of AC,

2. As the Co-fine of A, C, to the Co-fine of C! fo is the Co-fine of A, B, to the Co-fine of B, E.

And here observe, that to come to the knowled of C, E, in cases that resemble the first of the Di grams annexed, having found A, C, you are to dedu it out of A, E; again, in such cases as are like h second Diagram, A, E, ought to be deducted out A, C; and laftly in those that resemble the thin Diagram, A, C, and A, E, are to be added rogether

PROBL. 25.

In the same Triangles, A,B, and A, E together with the Angle A, being known, to find either of the other Angles, and namely (for Example) the Angle E.

AS the Radius to the Co-fine of A; to is the Tangent of A, B, to the Tangent of A, B 2. As the Sine of C, E, to the Sine of A, C; to is the Tangent of A, to the Tangent of E.

PROBL.

PROBL. 26.

A, B, and B, E, together with A, being known, to find A, E.

AS the Radius to the Co-fine of A; so is the Tangent of A, B; to the Tangent of A, C. 2. As the Co-fine of A, B, to the Cofine of B, E; so is the Co-fine of A, C, to the Cofine of C, E.

PROBL. 27.

A, B, and B, E, together with A, being known, to find B.

I. A S the Radius to the Co-fine of A, B; to is the Tangent of A, to the Co-tangent of A, B; C.

2. As the Tangent of B, E, to the Tangent of A, B; so is the Co-line of A, B, C, to the Co-line of C, B, E.

PROBL. 28.

A, and B, together with A, B, being known, to find either of the other Sides, and namely (for Example) the Side B, E.

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I. A S the Radius to the Co-fine of A, B; fois the Tangent of A, to the Co-tangent of A. B. C.

2. As the Co-fine of C, B, E; to the Co-fine of A, B, C; so is the Tangent of A, B, to the Tangent of B, E.

PROBL. 29.

A, and B, together with A, B, being known, to find E.

1. As the Radius to the Co-fine of A, B; so is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Sine of A, B, C, to the Sine of C; B; E; so is the Co-fine of A, to the Co-fine of E.

PROBL. 30.

A, and E, together with A, B, being known, to find A, E.

A S the Radius to the Co-fine of A; so is the Tangent of A, B, to the Tangent of A, C. 2. As the Tangent of E, to the Tangent of A; so is the Sine of A, C, to the Sine of C, E.

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PROBL. 31.

A, and E, together with A, B, being known, to find B.

i. A S the Radius to the Co-fine of A, B: 10 is the Tangent of A, to the Co-tangent of A, B, C.

2. As the Co-fine of \mathcal{A} , to the Co-fine of E: fo is the Sine of \mathcal{A} , \mathcal{B} , \mathcal{C} , to the Sine of \mathcal{C} , \mathcal{B} , \mathcal{E} .

PROBL. 32.

Three Sides being known, to find any of the Angles.

A Dd the three fides together, then from the half Sum thereof substract the fide opposite to the Angle required: this done, the Proportions will be as followeth:

ons will be as followers:

1. As the Radius to the Sine of one of the sides including the Angle required: so in the Sine of the other side including the same Angle to a fourth Sine.

2. As that fourth Sine is to the Sine of the half Sum of the fide: so is the Sine of the difference betwist that half Sum, and the side opposed to the Angle required, to a seventh Sine, betwist which and 90 d. (at the end of the Line of Sines) if you with your Compasses discover the half distance, that Point shall represent mits you an Ark, whose Complement being doubled is the Angle you look for.

So in the Diagram of the 6. Problem the fide A,

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B, being 30 d. the fide B, E, 18 d. 47 m. and the fide A, E, 42 d. 51 m. I demand the Angle 8: The Sum of the Sides is 91 d. 38 m. half that Sum i 45 d. 49 m. The fide A. E, being fubstracted on 4. of that half, there remains 2 d. 58 m. And there fore to discover the Angle B, proceed thus:

Batend the Compasses upon the Line of Sine from 90 d. unto 30 d. then applying that extent the fame way, and upon the same Line from 18 d. 47 % the movable Point will fall upon 9 d. 16 m. Again that Point remaining there fixed, extend the Conpasses so far that their other Point may rest upon 4 d. 49 m. this done, and that extent applied the fame way from 2 d. 58 m. will cause the movable Point a last to fall upon 13 d. 20 m. whose half distance to wards 90 d. will happen upon a Point representing 28 d. 42 m. whose Complement (viz. 60 d. 18.7) being doubled, amounts to 122 d. 36 m. the quantin of the Angle B required.

P R O B L. 33.

The three Angles being known, to find any of the Sides.

If in flead of the greatest Angle, you take in Complement to 180 d. the Angles convert them felves into fides, and the fides into Angles, and then (by confequent) the operation will be the family with that of the last Problem.

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Arain DRobl. 34. The Diameter of a Circle being known, to find the Circumference.

The extent upon the Line of Numbers from I to the Diameter, will reach from 3. 142 to the Circumference.

Probl. 35. To find the Superficial Contnt.

ce to The extent from I to the Diameter being twice enting repeated from .7854, will reach to the Content O, 8.7 otherwise thus: The extent upon the Great Line of antin Numbers, from I to the Diameter, will reach upon the Mean Line of Numbers from .7854 to the Content: Or yet thus; the Extent upon the Great Line of Numbers from I to .7854 will reach upon the Mean Line of Numbers from the Diameter to the Content. And in this manner may divers of the inluing Problems be diverfined, which (as before) I refer to the differetion of the Practioner.

Probl. 36. To find the fide of the Square, which may

be inscribed within the Same Circle. The extent from 1 to .7071 will reach from the

Diameter to the fide of the Square required. Probl. 37. Having the Circumference to find the Diameter.

The extent from 1 to .3183 will reach from the Circumference to the Diameter.

Probl. 38. To find the Superficial Content.

The extent from 1 to the Circumference being twice repeated from .07958, will reach to the Content. Or, &c.

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Probl. 39. To find the fide of the Square, which may Pro be inscribed within it.

The extent from 1 to the Circumference, will The reach from 2251 to the fide of the Square required from

Probl. 40. Having the Content of a Circle, to find to Pro Diameter.

The extent from 1 to 1. 273 will reach from their Foo Content to another number, whose Square Root is the Th Diameter required.

Probl. 41. To find the Circumference.

Feet, The extent from I to 12.57 will reach from the Pro Content to another Number, whole Square Root int the Circumference required. length

Probl. 42. To find the fide of the Square equal us Fir

to it.

Bxtract the Square Root thereof by the 12. Probleme d

of the last Chapter, and you have your desire. Mein Probl. 43. The breadth of a long Square being give engine in Inch-measure, and the length in Foot-measure, to suffect. the Content in Feet.

The extent from 12 to the breadth in Inches, will not in reach from the length in Feet to the Content in Feet of Or, vice versa, the extent from 12 to the length Th Feer, will reach from the breadth in Inches to the d

Probl. 44. The breadth and length of a long. Squareing being given in Foot-measure to find the Content there Feet. an Tards.

The extent from 9 to the breadth, will make le from the length to the Content in Yards. O:, &c. Pro Probl. 45. To find the Content in fingle Perches. Ind th

The extent from 16. 5 to the breadth, will read Th from the length to the Content in fingle Perchanis Or, Oc.

Probl. 46. To find the Content in Square Perches ; Pro therwise (in Architecture) called Poles.

The extent from 272. 25 to the breadth, will read To from the length to the Content in Poles. Or, or he le

Prob

ch may Probl. 47. The breadth and length of a long Square being given in Perches, to find the Content in Acres.

, wil The extent from 1.60 to the breadth, will reach

uired from the length to the Content in Acres. Or, &c.

find in Probl. 48. The breadth and depth of a Square Re-Hangle folid, being given in Inch-meafure, and the length om thein Fost-measure to find the Content thereof in Feet.

t is the The extent from 12 to the breadth or depth in Inches, being twice repeated from the length in Feet, will reach to the Content in Feet. Or, &c.

om the Probl. 49. The breadth and depth of a Rectangle folid Root int just square) being known) in Inch-measure, and the

moth in Fost-measure to find the Content in Feet.

wal so Find (by the tenth Problem of the last Chapter) the Mean Proportional betwixt the breadth and Probleme depth; for then, the extent from 12 to that Mem Proportional, being twice repeated from the

give ength in Feet, will reach to the Content in to fafeet.

Probl. 50. The breadth and depth of a Rectangle folides, will not just square) being known in Foot-measure, to find the

n Fee sofe or Superfices at the end thereof.

The extent from 1 to the breadth, will reach from to the depth to the Bafe required.

Probi. 51. The Base and length of a Restangle solid Squareing known in Ent-neafure, to find the Content in there Feet.

The extent from I to the Base, will reach from

Il reache length to the Content.

Gr. Probl. 52. Having the Diameter of a Cylinder, to es. Ind the Bafe.

read The Base of a Cylinder being a perfect Circle erchanis Problem may be refolved by the 35 aforetoing.

es; of Probl. 53. The Base and length of a Cylinder being nown, to find the Content.

read The extent from I to the Bale, will reach from

to he length to the Content. Prob

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Probl. 54. Having the Axis of a Spiere, to find the Sut

Superficial Content.

The extent from I to the Axis, being twice: peated from 3.142, will reach to the Superneial Co tent required. Or, oc.

Probl. 55. To find the foird Content.

The extent from I to the Axx, being thrice; peared from .5238, will reach to the folid Contents with quired. Or, ce.

CAP. VI.

The Use of the Rule of Proportio dius; the S in Astronomy. hour

PROBL. I.

By the Sun's Shadow, to find h height.

He extent upon the Mean Line of Number from the length of the Rules Shadow to height thereof (held Perpendicular to the rizon) will reach upon the Line of Tangents is 45 d. to the Sun's height required.

Probl. 2. The Sun's greatest Declination , 1000 with his distance from the next Equinoctial Point in known, to find his present Declination.

As the Radius to the Sine of the Sun's diffa from the next Equinoctial Point: fo is the Sin

find the Sun's greatest Declination to the Sine of the Dedination required.

wice Probl. 3. To find the Right Ascention.

As the Radius to the Tangent of his distance. ec. fo is the Co-fine of his greatest Declination to the Tangent of his Right Afcention.

rice: Probl. 4. The Sun's greatest Declination, together stem with his present Declination, being known, to find his

Right Ascension.

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As the Tangent of his greatest Declination to the Radius, fo is the Tangent of his present Declination to the Sine of his Right Ascention.

Probl. 5. The Elevation of the Pole, together with the Sun's Declination being known, to find how long the Sun

rifeth or fetteth before or after the hour of fix.

As the Co-tangent of the Elevation is to the Ra-The diss: so is the Tangent of the Sun's Declination to the Sine of the Ascentional Difference between the hour of fix, and the Sun's rifing or fetting.

Probl. 6. To find the Sun's Amplitude.

As the Co-fine of the Elevation is to the Sine of the Declination; so is the Radius to the Sine of the Amplitude.

Probl. 7. The Elevation of the Pole, the Sun's greatest Declination, and his distance from the next Equinoctial Point being known to find the Amplitude.

As the Co-fine of the Elevation is to the Sine of the Sun's distance; so is the Sine of the Sun's great-

est Declination to the Amplitude required.

Probl. 8. When the Sun is in the Equinoctial, by knowing the Elevation of the Pole, to find the Sun's height at any time assigned.

As the Radius to the Co-fine of the Elevation; To is the Sine of the Sun's diftance from fix a Clock int le

to the Sine of the height required.

Probl. 9. The Elevation of the Pole, and the Declina. diff tion of the Sine being known, to find the Sun's height at e Sim the hour of fix.

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As the Radius to the Sine of the Latitude : 6 the Sine of the Declination to the Sine of the her Sum required.

Probl. 10. To find the Sun's height at any time

figned.

1. As the Radius to the Co-tangent of the vation, fo is the Sine of the Sun's diftance for fix, to the Tangent of an Ark, which being fi tracted out of the Sun's diftance from the Fold fay again.

2. As the Co-fine of the Ark found is to Co-fine of the refidue of the Sun's diftance from Pole : fo is the Sine of the Elevation to the Sing

the height required.

Probl. 11. To find the time when the Sun will Sum

due East and West.

As the Tangent of the Elevation to the Rada ver t so is the Tangent of the Declination to the Condoub of the hour from the Meridian.

Probl. 12. To find the Sun's height, when he come

to be due East and West.

As the Sine of the Elevation to the Radius; fil the Sine of the Declination to the height required Probl. 13. To find the Sun's Azimuth at the in of fix.

As the Co-fine of the Elevation is to the 0 Tangent of the Declination; to is the Radius to Th

the Meridian.

Probl. 14. The Complement of Elevation, the Sa distance from the Pole, and the Complement of the Su

height being known, to find the Azimuth.

Having added the three given Terms togeth find the difference betwixt their half Sum and it Sun's distance from the Pole: this done, the h portion will be as followeth:

1. As the Radius to the Co-fine of the Elevation so is the Co-fine of the height to a fourth Sine:

2. As that fourth Sine is to the Sine of the half le ; i e her Sum; fo is the Sine of the difference to a feventh Sine, whose half distance towards 90 d. will discotime werthe Sine of an Ark, whose Complement being doubled is the Azimuth you look for.

Probl. 15. To find the hour of the Day.

the E Having added the three given Terms together. ace fin ing a before, find the difference betwixt their half Sum Folk and the Complement of the Sun's height : this done, the Proportions will be these:

1. As the Radius to the Co-fine of the Elevation : from to is the Sine of the Sun's distance from the Pole to

Sine a fourth Sine.

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2. As that fourth Sine is to the Sine of the half will Sum: fo is the Sine of the difference to a feventh Sine, whose half distance towards 90 d. will disco-Rada ver the Sine of an Ark, whose Complement being Cost doubled and converted into Time, will produce the hour required.

CAP. VII.

The Use of the Rule of Proportion in Dialling.

PROBL. 1. To make a direct Polar Dial.

vation Having affigned a Line drawn in the middle e: Line

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I ine drawn parallel unto it for some other hour, which Pr may be described upon the Plane: I fay,

t. As the Tangent of that hour is to the Radia vatio
fo is the distance of that Hour-line from the Me Tangent dian to the height of the Stile.

2. As the Radius is to the height of the Stile; 2. is the Tangent of any other hour, to the diffar on: of the same hour from the Substile.

Probl. 2. A Meridian Dial.

Having drawn a Line representing part of to is

Ass of the World towards a proper fide of to fit

Plane, (according to his fituation either Eastward the M

Westward) assigned that Line for the hour of 4. the Proportion will fall out to be as in the former habove blem: for.

is to the Badius to is to the Badius to the Badius to the Badius to is the 100 I. As the Tangent of any hours distance for and fix is to the Radius; so is the distance of the bashe in upon the Plane from the Hour-line of fix, to Pro

height of the Stile.

2. As the Radius is to the height of the Stile; on: is the Tangent of any other hours diftance from the Six to the diftance of the same hour from the Six stile.

Probl. 3. An Horizontal Dial.

As the Radius to the Tangent of the hour gire to is the Sine of the Elevation to the Tangent of Hour-line from the Meridian.

Probl. 4. A Vertical Dial.

As the Radius to the Tangent of the hour: heigh the Co-fine of the Elevation of the Tangent of Angle Hour-line from the Meridian.

Probl. 5. A Vertical Inclining Dial.

· Having found out the Elevation of the Pole bove the Plane, according to its inclination, the P fo is portion will be this:

As the Radius to the Tangent of the Hour the Su is the Sine of the Elevation above the Plane, we Tangent of the Hour-line from the Meridian.

ion:

r, whi Probl. 6. A Vertical Declining Dial.

I. As the Radius to the Co-tangent of the Ele-Radia varion: fo is the Sine of the Declination to the e Me Tangent of the Substile distance from the Meridian

of the Place.

itile; 2. As the Radius to the Co-fine of the Declinatidiffusion: fo is the Co-fine of the Elevation to the Sine of

the Stile's height above the Substile.

3. As the Sine of the Elevation is to the Radius: of the is the Tangent of the Declination to the Tangent of the Inclination of the Meridian of the Plane to want the Meridian of the Place.

of 4. As the Radius to the Sine of the Stile's height merhabove the Substile: so is the Tangent of the Angle at the Pole comprehended between the hour given ce to and the Meridian of the Plane, to the Tangent of the house Hour-lines distance from the Substile.

t, tot Probl. 7. A Meridian Inclining Dial.

I. As the Radius to the Tangent of the Elevation: fo is the Sine of the Inclination to the Tangent of the Substile's distance from the Meridian.

2. As the Radius is to the Sine of the Elevation: fo is the Co-fine of the Inclination to the Sine of the

Stile's height above the Substile.

Stile's height above the Substile.

3. As the Co-sine of the Elevation is to the Radit of w: so is the Tangent of the Inclination, to the Tangent of the Inclination of Meridians.

4. As the Radius is to the Sine of the Stile's ur: height above the Substile: so is the Tangent of the tof Angle at the Pole, to the Tangent of the Hour-lines distance from the Substile.

Probl. 8. A Pelar Declining Dial.

Pole 1. As the Radius to the Sine of the Declination : the ho is the Co-fine of the Elevation to the Co-fine of the Ark comprehended between the Horizon and

2. As the Radius to the Tangent of the Decline-Profice : fo is the Sine of the Elevation to the Tan-

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Cap. VII Chap gent of the Inclination of Meridians, which bei converted into time, theweth how many hound 7. I Subfile ought to be placed from the Hour hubfil of II. Pole,

3. As the Radius is to the Tangent of the horiom to diffance from the Subfile : fo are the parts of the height of the Stile, to the distance of the Subfil from the Hour-line required, measured by a Scale like parts.

Probl. 9. A Declining Inclining Dial.

I. As the Radius to the Tangent of Inclination to the Horizon : so is the Co-fine of Declination to the Tangent of the Ark of the Meridian of the Place intercepted between the Horizon and the Plane, which being compared with the Elevation the Pole, the diffance of the Pole from the Plan may be thereby readily discovered.

2. As the Radius is to the Sine of Declination Prob from the Vertical: To is the Sine of Inclination the Horizon, to the Co-fine of the Inclination to

Meridian.

3. As the Radius is to the Co-fine of Inclination to the Horizon: fo is the Cotangent of Dedicate tion to the Tangent of the Ark of the Plane in . V Place.

4. As the Radius is to the Sine of the Inclinate for L to the Meridian : fo is the Tangent of the Pole's painder flance from the Plane, to the Tangent of the Si 2. 1 ftile's distance from the Meridian.

5. As the Radius is to the Pole's diffance funat, are Plane: fo is the Sing of the the Plane: fo is the Sine of the Inclination to the: Meridian, to the Sine of the Stile's height about h Prob the Substile.

6. As the Cofine of the Pole's distance from thing pro Plane is to the Radius: To is the Cotangent of a 1. Inclination to the Meridian, to the Tangent of oder Inclination of Meridians. Inclination of Meridians. 7. Since y ound 7. As the Radius is to the Stiles height above the purlimbilities to is the Tangent of the Angle at the ole, to the Tangent of the Hour-line's diffance e hor from the Substile.

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CAP. VIII.

of The Use of the Rule of Proportion in Geography.

linam robl. 1. Two Places being propounded, which differ only in Latitude, to find their Distance.

e im. W Hen the two places are fituate under the time Meridian, and upon the time fide of the Equinoctial; Substract the inmit for Latitude out of the greater; that done, the re-

ole's ainder & the distance required.

he St 2. When one of the places propounded is fituate on this fide the Equinoctial, and the other upon centar, and yet both under the fime Meridian, as beto the: Add the two Latitudes together; the done, their t aboum n the distance required.

Probl. 2. Two places, which differ only in Longitude,

combing propunded, to know their distance.

of a I. When the Places are both of them fituate of inder the Equinoctial: Saturatt the leffer Lingstude tof the greater: this done, theremainder is the di-7. Ince required.

2. When the Places are fituate under some Paul betwixt the Equinoctial and one of the Poles: In state Radius is to the Cosine of the common Latin given: so is the Sine of half the difference of Longisto the Sine of half the distance.

Probl. 3. Two places being given, which differ to in Longitude and Latitude, to find their distance.

1. When one of the Places is fituate under the quinoctial, and the other towards one of the Pol Then, As the Radius is to the Co-fine of the different for Longitude: so is the Co-fine of the Latitude go

to the Cofine of the distance required.

2. When both Places are without the Equinod and towards one of the Poles: Then, As the Rai Prosite to the Co-sine of the difference of Longitude: six Co-tangent of the lesser Latitude to the Tangent of a there Ark, which being substracted out of the Coplement of the lesser Latitude, retain the Ark the of remaining; and say again, As the Co-sine of Ark sound is to the Co-sine of the Ark remaining; in the Sine of the lesser Latitude to the Co-sine of the stance required.

3. When both Places are without the Equinon and one of them situate towards the North Pole, the Sthe other towards the South: say thus, As the Be Latitus is to the Co-sine of the difference of Longitude: the Recetangent of one of the Latitudes, to the Tangal another Ark, which being substracted out of other Latitude, and 90 d. added together: say at the Ast the Co-sine of the Ark found is to the Co-sine of the Ark found is to the Co-sine of the Latitude that taken, to the Co-sine of the distance required.

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CAP. IX.

er the the Par The Use of the Rule of Proportidiffere on in Navigation. ude giu

he Rai Probl. 1. The Latitudes of two Places being known, to find the Meridional Difference.

of the f. W Hen one of the Places is fituate under the Equinoctial, and the other without: The Degrees and Decimal Minutes found upon Pole, the Scale of Equal Parts at the Point; where that other the Ba Latitude is represented upon the Scale of Latitudes, are ude: the Meridional difference required.

Tange 2. When one of the Places have Southerly, and at of the other Northerly Latitude: Extend the Compaf-Say an fes upon the Line of Latitude, from the beginning of ne of that Line to the leffer Latitude : that done, if you apply tude that extent upon the same Line, and the same way from the greater Latitude, the movable Point will discover upon the Line of equal Parts, the Meridional difference desired.

3. When both Places have Northerly or Southerly Latitude: Extend the Compasses upon the Line of Latitudes from one of the Latitudes to the other: this done, if you apply that extent from the leginning of Line, the movable Point will shew you upon the Scal che ditt Egual Parts the Meridianal difference you look for.

Probl. 2. The Latitudes of tres places together; their difference of Longitude being known, to find

Rumle directing ir mathe one to the other.

As the Meridional difference is to the difference of Longitude: fo is the Radius to the Tanger the Rumbe : And therefore,

The extent upon the Mean Line of Numbers from Moridional difference to the difference of Longitude, reach upon the Line of Tangents from 45 d. to the L

gent of the Rumbe.

And note here, that in this Problem and the li you may make use of the double Scale, placed up the lift Line of the Rule of Proportion, at the of the Scale of Inches: viz. (if need be) for t more speedy reduction of the Sexagenary Minutes the Longitude into Decimals, & contra : to thee you may by that means the more readily work them upon the Mean Line of Numbers.

Probl. 3. By both Latitudes and Rumbe to finds

distance upon the Rumbe.

As the Co-fine of the Rumbe to the true different of Latitudes: fo is the Radius to the distance my the on

red: And therefore,

Extend the Compasses acres from the Co-fine of t Rumbe (found upon the Line of Sines) to the true af rence of Latitudes (found upon the Mean Line of No bers) this done, if you apply that extent the same m and acres from 90 d. upon the Line of Sines, the m vable Pant will frew you upon the Mean Line of No bers (in Degrees and Decimal Minutes) the distance n quired.

Probl. 4. By both Latitudes and Rumbe, to find

difference of Longitude.

As the Radius to the Tangent of the Rumb to is the Meridienal difference of the Latitudes

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e See the difference of Longitude required : And therefore The extent upon the Line of Tangents from 45 d. to the Tingen f the Rumbe, will reach up at the Mean Line of Numbers from the Meridional difference of the Latitudes to the difference of Longitude required.

Probl. 5. By both Lainudes and distance to find the

ngem Rumbe.

As the distance is to the true difference of Latifrom tudes: fo is the Radius to the Co-line of the Rumbe: ade, And therefore,

the L The extent up in the Mean Line of Numbers, from the distance to the difference of Latitudes, will reach upon the he I Line f Sines 1.cm od to the C-jine f the Rumbe.

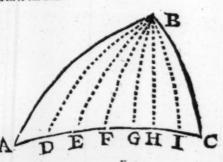
Probl. 6. By one Latitude, distance, and Rambe, to

he e find the staer Latitude.

As the Radius to the Co-ine of the Rumbe : fo is for t the diffance to the true difference of Latitudes : And autes (therefore, the a

The excent upon the Line of Sines from 90 d. to the Co-fine of the Rumbe, will reach upon the Mean Line of Numbers, from the distance to the true difference of Lafinds tundes.

Probl. 7. The Latitudes and difference of Longitude Feren ten of two places being witton, to fall by the great Circle from the one to the other.



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In the Triangle A, B, C, let A represent S.O. stephers, C, the Lazard, B, the North Pole, A, B, Complement of the Latitude of S. Christophers, 74 d. 30 m. B, C. the Complement of the Latin of the Lizard, 40 d. 0 m. and A, B, C, the different of Longitude, 68 d. 30 m. Now therefore to the a course from A to C alongst the Ark A, C, promethus:

1. By the 24 and 25 Problems of the fifth Chaps find the fide A, C, as also the Angles A, and C.

2. By the 22 of the fime Chapter find the le Pendicular B, J, cutting the fide A, C, at R. Angles.

3. By the 8 of the sime discover the Angle 4.

I, and by the 9 the fide A, I.

4. Lestening the Angle A, B, I, two, five, or Degrees, as you shall see cause, (for Example, by Angle A, B, d,) by the knowledge of the Angle B, I, and of the fide B, I, find by the 11, 12, and Problems of the same fifth Chapter, the Base B, d, fide d. I, and the Angle B, d, I; and so proceeding do the like at the Points e, f, g, and h, you may the by discover the several distances betwixt Point a Point, the feveral Latitudes at those Points, and feveral Angles according to which you are to die your Courle : For at first, from A you are to se according to the Angle B, A, I, until you shall he failed fo many Leagues as answer to the distance h twixt A and d: and then from d, according to Angle B, d, I, untill you shall arrive at the Point according to the number of Leagues that d and are diffant the one from the other; and fo con quently of the rest in their order, until you shall a tain the Point I, from whence you are to fteer West towards c, the Angle B, I, C; being a Right Angle, &c.

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CAP. X.

The Use of the Rule of Proportion in the Gaging of Vessels.

Probl. 1. The true Content of a Solid Measure being known, to sindthe Gage Point of the same Measure.

The Gage Point of a folid Measure is the Diameter of a Circle, whose Superficial Content is equal to the folid Content of the same Measure so the folid Content of a Wine-gallon (according to Winehester measure) being 231 Cube-inches, if you conceive a Circle to contain so many Inches, you shall find so the fortieth Problem of the fifth Chapter) the Diameter thereof to be 17.15: For,

As 1 is to 1.273: fi is 231 to 294. 1, whose Square rat (by the twelth Problem of the same Chapter) is 17.

15, the Gage-point of Wine-meafure.

Thus likewise may you easily discover the Gagepoint of Ale-measure, an Ale-gallon (as it hath been of late discovered) containing 288 Cube-inches: For,

As I no 1. 273: so n 288 to 366. 7, while Square-root is 19.15; the Gage-point of Ale-measure.

And

And (indeed) 283 Cube-inches feem to be Diame most probable Content of an Ale-gallon, being Bongs fixth part of 1728, which is the Number of Ch Equat inches contained in a Cube-foot. For fo (according Exto that account) a Cube-foot contains just fix Galler Inches and the Gage-point of Ale-measure (by reason of mand foil and wafte) exceeds that of Wine-meafire i Comp

After the same manner also may you discover the b Gage-point of any Forreign measure whatsoever, a vable afterwards by that means come to the knowledges differ the true Content of their Vessel, according to his still Measures used amongst them, as will plainly apper fixed by that which shall hereafter be taught for the die till th very of the Contents of Wine and Beer-veffel accord and a

ing to the English Measures.

Now from that which is above faid doth necessary 20. 5 follow this Corollary: When the Diameter of a Colinda by th an C in Inches is equal to the Goge-point of any Meafere (goa likewife in Inches) every Inch in the length there f comian perfe one Integer of the same Measure: So in a Cylinder having 17.15 Inches Dianieter, every Inch inth length thereof contains one intire Winc-gallon : and in another having 19.15 Inches Diameter, every lin thereof contains one Ak-gallon, &c.

Probl. 2. In a Wine or Beer-veffel, the Diameters the Head and Bengue being known, to find the required

Diameter.

Extend the Compasses upon the Line of Inches from the Diameter at the Head, to the Diameter at the Bongue: then applying that extent from the beginning of the same Line, and observing there the de ference betwixt the two Diameters, (one of the Points remaining fill fixed at the beginning of the Line) close the Compasies till the other Point my fall upon to many parts of the Gage-line, as the diffe rence between the two Diameters, amounts unto it Inches; this done, and that extent applied from the

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be Diameter at the Head towards the Diameter at the ting Bongue, will cause the movable Point to fall upon the

f Can Equated Diameter you look for.

cords Example, The Diameter at the Head being 18. 3 Gallo Inches, and that at the Bongue 21.5 Inches, I den of mand the Equated Diameter. First, extending the The Compasses upon the Line of Inches from 18.3 Inthes to 21.5, and then applying that extent from were the beginning of the same Line, I find the morer, a vable Point ro fall upon 3.2 Inches, viz. the true edged difference of the two Diameters: Now therefore to bif still keeping one of the Points of the Compasses appe fixed at the beginning of that Line, I close them dios till the other Point may fall at 3. 2 upon the Gage-line, accord and after apply that extent from 18. 3 (the Diame er at the Head) the movable Point will at last fall upon effart 20.54 Inches, the Equated Diameter required. And Minds by this means your Veffel, which before was in part of (gra an Oval form and irregular, is now reduced into a emain perfect Clinder.

linder Probi. 2. The equated Diameter and length of a Wine inth or Beer-veffel being given in Inches, to find the Content

theref in Wine-measure. : 30

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The extent upon the Line of Numbers from 17.15. (the Gage-point of Wine-measure) to the Equated tene Diameter, being twice repeated from the length, will reach to the Consent in Wine-gallons.

Probl. 4. To find the Content in Ale-me fure.

The extent from 19. 15 (the Gage-point of Alemeasure) to the Equated Di merer; being twice reat the reated from the length, will reach to the content in ocgire de Ak-gallons.

Probl. 5. Having the length and the two Diameters fin the at the Head and Bongue, together with the Equated Dias meter and Content of a Vegit, and f which for ranch and em s no more of the ligner is comen that the Superficies diffe thereof may cut fine part of the head, to find the true to it

quantity of the remainder. n the

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Deduct half the difference of the Diameters at Head and Bongue, out of the diffance interest between the Bongue and the Superficies of the Ligato the end you may thereby diffeover where the quor within the Veffel cuts the Head, according which draw a Line with Chalke (or otherwife) up the Head, then having drawn another Line parallel the first, and of like distance from the other opposition of the Head, you have in the middle of the Bobetwixt those two Lines a Segment of the Vemarked out, and likewise two other Segment, it one above and the other below that middle Segment after this taking the length of one of those Parallel in Inch-measure, the Equated Diameter of the Superficies may be thus found out upon the Rule:

The extent from the Diameter at the Head to the Equited Diameter of the Vessel, will reach from the length one of the Parallels to the Equated Diameter of the

perficies.

Then having discovered (by the 2d Problem afor going) the Equated Diameter of those two others quated Diameters, find (by the tenth Problem of the fourth Chapter) the Mean Proportional betweenth third Equated Diameter and the diftance betweenth two Parallels: This done, make use of that Mean In portional, as an Equated Diameter of the middle & ment, and then finding by one of the two last h blems according to the Question propounded) the Co tent thereof in Gallons, &c. deduct that Content of of the whole Content of the Veffel: All this pe formed, when the Veffel is above half full, the Conte of that middle Segment and half that remainder by ing added together; is the Content you look for. Bu when the vessel is not half full, half that remainder the Content defired.

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CAP. XI.

The Use of the Rule of Proportion in Military Orders.

Probl. 1. Any Number of Soldiers being propounded, to order them into a Square Battail of Men.

Find (by the twelfth Problem aforegoing (the Square-root of the Number given: For, look how much that Root shall happen to be, so many Soldiers oughr you to place in Rank, and to many likewife in File, to make a Square Battail of Men.

Example; Let it be required to order 573 Soldiers into a Square Battail of Men: the Square-root of that Number is 23.94 : and therefore you are to place 23 in Rank, and as many alfo in File: For; Fractions are not confiderable in Questions that concern, Military Orders.

Probl. 2. Any Number of Souldiers being propounded to order them into a double Battail of Mes: viz. which may have twice so many in Rank as in File.

Find out the Square-root of half the Number given: for that Root is the Number of Soldiers to be placed in File: and to many more ought to be. placed..

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placed in Rank, to make up a double Battail of

Example, 1342 Souldiers being propoueded to be put into that order: I find 26, &c. to be the Square-root of 671 (half the Number propounded) and there upon conclude that 26 ought to be placed in File, and 52 in Rank, to order so many Soldiers into a double Battail of Men.

Probl. 3. Any Number of Soldiers being given, to order them into a quadruple Battail: viz. fuch as may have four times so many in Rank as in File.

Here the Square-root of the fourth part of the Number given will show the Number to be placed in File, and sometimes so many are to be placed in Ranka

So 2048 Soldiers being offered to be pur into that order, 22 are to be placed in File, and 88 in Rank. For, the fourth part of 2048 is \$12, whole Square-root is 22, &c.

Probl. 4. Any Number of Soldiers being given, togther with their distance in Kank and File, to order them

into a Square Battail of Ground.

Extend the Compasses upon the Mean Line of Numbers from the distance in File to the distance in Rank: this done, and that extent applied the same way, and upon the same. Line from the Number of Soldiers propounded, will cause the movable Point of all upon a fourth Number, whose Square-root appearing at the same Point upon the Great Line of Numbers is the whole Number of Men to be placed in File: bywhich if you divide the Number of Men to be placed in Rank.

Example, 2500 Men are propounded to be ordered into a Square Battail of Ground, in such fort that their diffiance in File being seven foot, and their diffiance in Rank three foot, the Ground whereupon they fland may be a just Square. To resolve this Question, extend the Compasses upon the Mean Line

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tail of Numbers downwards from 7 to 3: then (because he fourth Number to be found in all likelihood will confift of four Figures) if you apply that extent the fime way from 2500 in the first part of the Gime line, the movable Point will fall upon the fourth Number you look for, where also you may observe 32, Or. upon the fecond part of the Great Line of Numbers, which are the Number of Men to be placed in File; again, if letting that Point of the Compaffes remain fixed there, you close them till the other Point may reach crof-wife to I at the beginning of the first part of the faid Great Line of Numbers, that extent being applied the same way (viz. downwards and acros) from 2500 upon the fime Great Line, the movable Point will fall near 26, &c. which are the Number of Soldiers to be pleced in Rank.

Probl. 5. Any Number of Soldiers Leing propounded, to order them in Rank and File according to the reason of

any troo Numbers given.

This Problem is refolved much after the fime man-

ner that the last was: For,

As the Proportional Number given for the File is to that given for the Rank : fo is the Number of Sculdiers to a fourth Number , whose Rost is the Number of Men to be placed in Rank, by which if you divide the whole,

the Quotient is the Number to be placed in File.

So if 2500 Soldiers were to be martialled in fuch order, that the Number of Men to be placed in File might bear fuch proportion to the Number of Men to be placed in Rank, as 5 bears to 12: I fay then, as 5 is to 12, fo is 2500 to another Number, whose Root is 77, &c. viz. the Number of Men to be placed in Rank, by which if the fime 2500 be divided, the Quotient will be 32, or, the Number of Men to be placed in File.

CAP. XII.

The Use of the Rule of Proporti apply on in Questions that concern pound Interest and Annuities.

Probl. I. A Sum of Money being of 8 forborn for a certain time, to find how much it will be augmented at the expiration of the same time, accounting Interest upon Interest, according to a certain rate propounded.

He extent upon the Line of Numbers from 100 l. to the aggregate of 100 l. and the ran added together, being repeated the fame war from the Sum given, so many times as there are years in the Question, will at last cause the movable Point to fall upon the Principal increased with the Interest, according to the forbearance and rate propounded.

Example, I defire to know how much 273 l. be ing forborn for five years will be increased at the expiration of those years according to Interest up

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m Interest, and the rate of 8 l. per centum: Extend Compasses upon the great Line of Numbers fom 100 to 108: This done, if that extent be repeared five times from 273, the movable Point will glaft fall upon 402. I (viz. 402 l. 2 s.) the Principal agmented with the Interest for the forbearance of those five years.

Probl. 2. A Sum of Money being due at a time to

come, to find what it is worth in ready Money.

This is the Inverse of the last: for here, if you apply that extent backwards from the Number propounded, so many times as there are years in the Que-

ftion, you shall have your defire.

Example, 4021. 2 s. being due at the end of five years yet to come, I defire to know how much that Sum is worth in ready Money according to the rate of 8 l. per centum: Extend the Compasses from 100 reing to 108, as before: And then, if you apply that extent five times downwards from 402. 1, the movable Point will at last fall upon 273 l. the value of 402. 1, in ready Money. unt-

Probl. 3. A yearly Rent or Annuity being furborn time a certain Number of years, to find what the Arrearagu thereof poil amount unto according to any rate pre-

psunded.

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the

First discover the principal that answers to the Rent or Annuity in question, then find unto what Sum that Principal will be augmented (according to. the given rate) at the end of the Term propounded: This done, if you substract the same Principal out of that Sum, the remainder is the Sum of the Arrearages are

able you look for. Example, A Rent or Annuity of 12 l. per annum the being forborn 16 years, what will the Arrearages 100thereof amount unto, they being conceived to increale (as they grow due) after the rate of 8 l. per centum. Here first, to find the Principal that anfivers to 12 1. fay thus: If 8 1. hath 100 1. for his Principal,

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Principal, what ought 12 l. to have for his? the fiver will be (by the fourth Problem of the four Chapter) 150 l. Having thus discovered the Principal of 12 l. viz. 150 l. I find (by the first Problem of this Chapter) that the same 150 l. being forbit 16 years will amount (after the rate of 8 l. paratum) to 513. 2, that is 513 l. 18 s. Now that if I deduct 150 l. (the Correspondent Principals the Annuity giver) out of 513 l. 18 s. the remaind viz. 363 l. 18 s. is the Sum of the Arearages repred.

Probl. 4. A yearly Rent or Annuity being propeded, to find what it is worth in ready money.

First, find what the Arrearages thereof amounts to at the end of the Term propounded, and in what those Arrearages are worth in ready mon which shall likewise be the required price or which

of the Rent or Annuity propounded.

Example, What may a man which is desirous lay out his money after the rate of 8 l. per cents afford to give for a Lease of 12 l. per annum thath yet 16 years in being? I find (by the last holem) that the Arrearages of 12 l. per annum, but torborn 16 years, amount then unto 363 l. 18 le 363. 9, and I find likewise (by the second Press aforegoing) that the same 363 l. 18 s. is worth in passent money 106. 2, or (which is all one) 106 l. 4 l. conclude therefore that the value of the Lease prounded (at the rate of 8 l. per centum) is 106 l. 4.

Here, when the Term of the Annuity begins in presently, but after certain years to come, find with the Arrearages forborn for all that time are worth

ready money.

So in the Example last premised, if the Annuity of years were not to begin till after the expirate of 5 years, in this case you are to enquire what the Arrearages (viz. 363 l. 18 s. being forborn 21 years worth in ready money, which you shall likewish

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find (by the fecond Problem before cited) to be 72. 3, ? thea which being reduced is 72 l. 6 s. the value of the Leafe required. he Prin

Probl. 5. A Sum of Money being propounded, to feed what Annuity (to continue any Number of Years, and

according to any rate given) that Suns wis buy.

Take any Annuity at pleafure, then find the value of that Annuity in ready money: This done, the Proportion will be as followeth:

As the value found is to the Annuity taken; fo is

the Sum given to the Annuity required.

Example, What Annuity (to continue 16 Years) will 1205 1. deferve, fo that the purchaser may gain after the rate of 8 l. per centum? Here, first, I take 12 l. per annum to continue 16 years, and find the value thereof in ready money (by the last Problem) mon tobe 106. 2, or 106 l. 4 s. I fly therefore,

. If 106. 2 give 12 l. per annum.

What will 1205 l. yield? Facit 171,4 per annum, which being reduced is 171 l. 8 s. I conclude therefore, that 171 l. 8 s. is the Annuity (to endure 16 years) which 1205 l. doth deserve, after the rate of 8 l. per centum.

Deo Laus.

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